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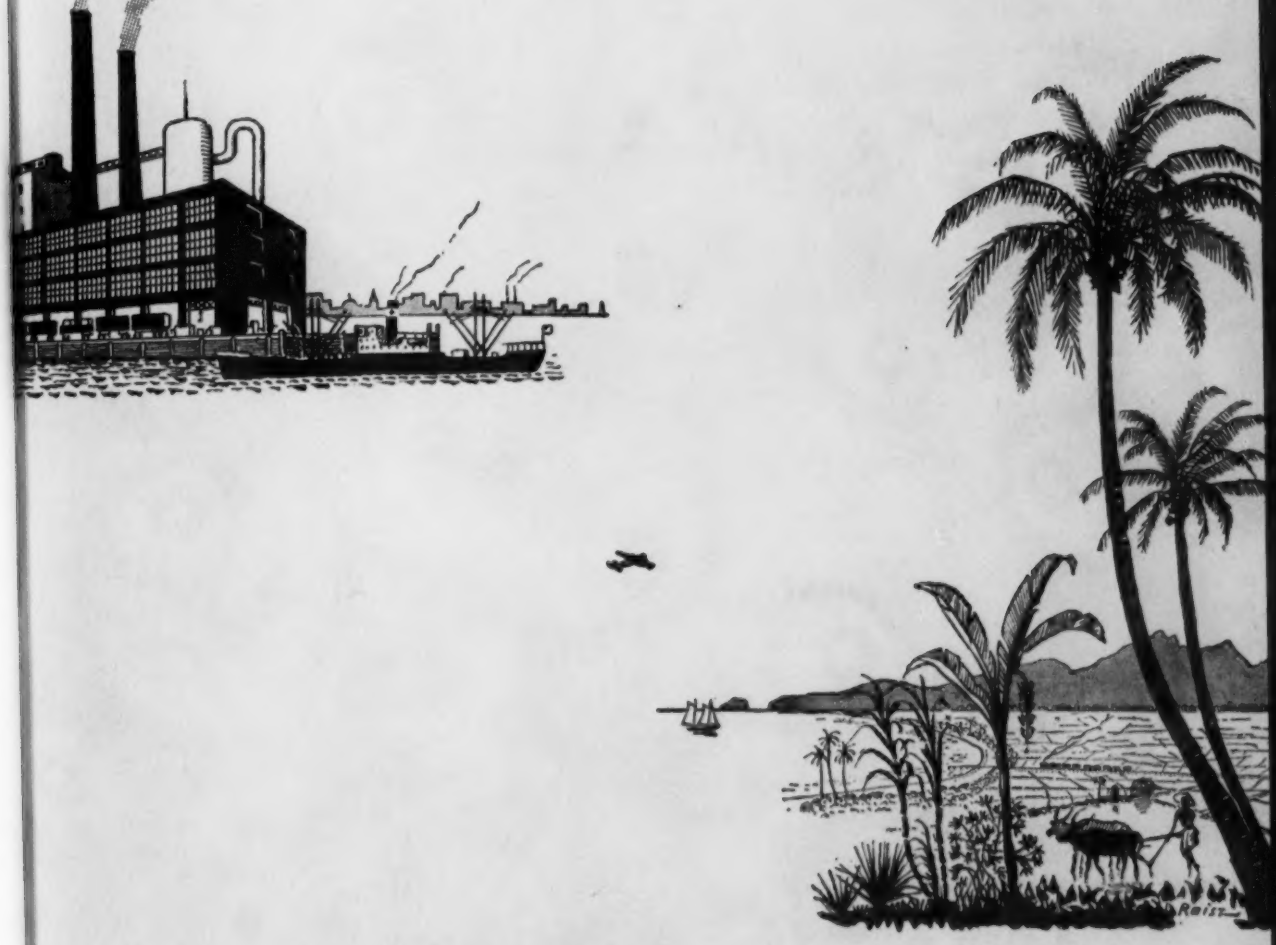

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This magazine publishes articles in the field of economic geography as well as articles in adjacent fields that contribute to an understanding of the world's economic patterns.

Authors are requested to send with each article a statement as to the field work, special experience, or other background on which the article is based. They are also urged whenever possible to submit maps and graphs in such form that they can be reproduced directly. In cases where it is necessary these will be redrawn at the editorial offices, but this may result in delay in publication. Delay will be avoided, also, if the author will send a caption with each illustration. All map or chart captions should show the source of data or other information unless this is already given in the illustrations. The sources of information for all tables, too, should be shown. Wherever a photograph is used that was not taken by the author, some source credit should appear in the caption.

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ECONOMIC GEOGRAPHY

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A REPORT TO THE PROFESSION

ECONOMIC GEOGRAPHY serves the whole geography profession. Though the magazine is published at Clark University, its pages are open on an equal basis to all persons writing articles of value in its special field. The only criterion is quality; the magazine's guiding policy is to publish the best material available. Because of his feeling of responsibility to the profession the editor proposes from time to time to make a report on problems and progress. This is the first of these reports.

Let us begin with the size of the magazine. Your October ECONOMIC GEOGRAPHY will be 16 pages longer than the July issue. In October, 1943, Dr. Ekblaw, who was then editor, announced a 16-page reduction. This was necessitated by a dearth of manuscripts combined with a paper shortage and other difficulties incident to the War. The reduction was intended only as a temporary measure, but increased printing costs and other problems delayed resumption of the larger size. Now the time has come to return to 96 pages, the length that prevailed in 1943. In view of the current shortage of publishing space, a problem that faces the whole expanding geography profession, an even greater increase in the size of ECONOMIC GEOGRAPHY obviously would be desirable. It is a possibility for the future.

This brings up another, related matter: support from the geography profession. The future of the magazine—its size, in fact its very existence—depends upon such support. ECONOMIC GEOGRAPHY's present circulation of between fourteen and fifteen hundred represents an increase of more than 200 in the last six months. This increased support is encouraging, but a circulation of two or three thousand seems a not unreasonable goal. As part of a subscription campaign a special student introductory rate recently was instituted. This will be continued, and extended so that renewals at the same rate will be allowed as long as student status is maintained. Members of the profession can help by calling this rate to the attention of their students.

Several other matters should be mentioned. (1) A problem in the past has been that of *getting the magazine out on time*. This was an impossibility during the War, but now you can count on your copy being mailed within a day or two of its scheduled time. (2) For any magazine that has been appearing as long as ECONOMIC GEOGRAPHY a cumulative index is desirable. In the April issue a 25-year index was announced. This is now in preparation and will be available in the fall. (3) Finally, there is the problem of quality. The prospects in this regard are promising indeed, since an unprecedented number of good manuscripts is arriving. Although many have to be refused because of lack of space, the long-run effect of this over-supply should be a higher quality product. Gratifying cooperation is being received, too, in the matter of book reviews.

The editor would like to end this report with a request. Why not send in your comments? If you like an article, tell us so; if you have suggestions for improving the magazine we'd like to hear them. Obviously, not all suggestions can be followed, but just as obviously the magazine should not be a one-man show. It is only through such help that the editor can hope to make ECONOMIC GEOGRAPHY truly representative of the profession.

R. E. M.

ECONOMIC GEOGRAPHY

VOL. 26 JULY, 1950 NO. 3

THE SIGNIFICANCE OF INDUSTRIALIZATION IN LATIN AMERICA

Preston E. James

Dr. James, professor of geography at Syracuse University, is an authority on Latin America.

THE transformation of a pre-industrial, agrarian society to an urban-industrial society is a fundamental cause of conflict in present-day Latin America. Underneath the political, economic, and social frictions which take a somewhat different form in each country, there is a basic change taking place in the ways of living.

Industrialization, which had its beginnings around the shores of the North Sea nearly two centuries ago, has spread in ever widening circles from that nuclear area. To some countries it came easily; to others, especially those in which industrial and agrarian areas were geographically separate as in Spain and the United States, the conflict even developed into civil war. But in any case, the change from a rural society consisting of a small minority of wealthy landowners and a great majority of illiterate agriculturists, to one consisting of a small group of owners of capital and literate wage workers necessitated basic revisions of long-established institutions and habits of thought. In Latin America the development of the industrial way of living is today going forward at such a rapid pace that the old way of life of the story books and the movies has already disappeared in many places. The flavor of the traditional pre-industrial Latin America with its picturesque people, its gauchos and guitars, is to be found today only in remote places difficult of access from the outside world.

As usual, however, over-all statistics of industrial growth obscure the very significant differences in the rate and degree of development. The outstanding centers of manufacturing industry are São Paulo, Buenos Aires, Rio de Janeiro, Mexico City, and Santiago, with several of the smaller cities of Chile, Colombia, and Mexico not far behind. The largest single industrial area is around São Paulo and Rio de Janeiro in Brazil, supported now by Volta Redonda between the two cities. But the country which has gone farthest in transforming its way of living is Chile. Argentina, with the largest per capita income of all the Latin American countries, bases its prosperity in part on the great agricultural and pastoral productivity of the Humid Pampa, and to a lesser extent on industry.

STATISTICS OBSCURE THE SIGNIFICANT FACTS

The statistics of industrialization commonly available are poor indicators of the growth of the industrial way of

living. This is due to the fact that all industrial establishments are counted, and there is no distinction made between the large-scale, low-cost per unit factory, employing many workers and involving a large capital investment, and the small-scale, high-cost per unit factory or workshop, in which only a few workers are employed and in which the capital investment is small. In Colombia, for example, more than 70 per cent of all the establishments listed as industrial about 1940 had a capital investment of less than $5,500. The average number of employees per plant in Colombia was only about eight; in Argentina and Brazil about 16; and in Chile about 27. In comparison the average number of workers per plant in the United States was about 42. In other words only a small fraction of the plants listed in Latin American countries ought to be considered as large-scale operations. The workshop is characteristic of the traditional pre-industrial society; the large-scale factory is the symbol of the industrial society.

HANDICAPS TO INDUSTRIALIZATION

Industrialization in Latin America faces four major difficulties. The first is the prevailing poverty and widespread illiteracy of the people. This handicaps the successful operation of an industrial plant in two ways. It restricts the market for manufactured products because only a small proportion of the people have enough income to purchase such goods even if they should want to do so. In fact, the advertising of an attractive gadget in a city where less than 10 per cent of the people can afford to buy the gadget might be one of the most effective ways to develop the atmosphere of revolution. And poverty and illiteracy also reduce the supply of skilled workers needed in the factories. This condition is remedied over a period of years, however, because the presence of opportunities for employment brings people together in cities where the children can be educated, where there are better health conditions and better diet than in rural areas, and where workers can be trained.

The second major handicap to the progress of industrialization is the traditional attitude of the well-to-do people. In the pre-industrial society prestige is gained by the ownership of land. To invest surplus funds, even in agricultural enterprises, for the purpose of increasing production or of lowering costs is not the usual way of using such funds. In the major urban centers of Latin America, and in such unusual agricultural areas as Cuba and São Paulo state, many Latin Americans have already changed their attitude toward investments, and prestige is now actually derived from the ownership of capital. For many years to come, however, industrialization must depend to a considerable degree on foreign investors; and under present world conditions this means chiefly individuals in the United States who are willing to risk investments abroad for the sake of the large returns they bring.

The third handicap is the prevalence of a concept inherited from the pre-industrial society—the concept of national self-sufficiency. Industrial plants can produce things people want at low enough cost per unit so that the material well-being of the people is greatly increased. But this can only be done if large quantities of goods are produced, and if the raw materials are brought to the plant from the lowest-cost sources. The idea that every country must make use of its own raw materials even at high cost, or that every country must have its own steel plant as the basis for industrialization, is an idea which could eventually destroy the

capitalist system if it is not overcome in time. Argentina, for example, has a world advantage in the manufacture of things from wool, hides, meats, grains, and the other special products she can supply at low cost. But to use government subsidies to build and protect a steel industry based entirely on imported raw materials can only mean high-cost goods, and eventual economic disaster. There are only two alternatives: to accept international interdependence and give up the concept of national self-sufficiency, or to accept the idea that all labor is for the good of the state and to give up the hope of decreasing costs. At present too many persons in Latin America are inclined toward the second alternative.

And finally, the fourth handicap to industrialization is the generally inadequate development of the means of transportation. The isolated pattern of clusters which characterizes the geography of man in Latin America is still a principal characteristic. With certain notable exceptions, the railroad lines are so cheaply built and so poorly integrated with the pattern of settlement that the movement of goods is still very costly. All-weather highways are also rare, and in many cases where they appear to provide access to a wide extent of country, a close examination shows that the weakness of certain key bridges make their use for heavy loads impossible. With high costs of transportation the small, high-cost workshops are effectively protected from the competition of low-cost goods from the large-scale factories.

Yet the progress of industrialization is something to watch. Already it makes Chile something quite different from the "land and society" described by McBride in the 1930's. It underlies the political conflicts, such as those which produced Perón. To understand present-day Latin America a much more penetrating study of the geography of large-scale industries is needed than has yet appeared.

THE GEOGRAPHY OF NATURAL GAS IN THE UNITED STATES

James J. Parsons

Dr. Parsons is Instructor in Geography at the University of California, Berkeley. He is the author of several articles in the GEOGRAPHICAL REVIEW *and of a monograph on Antioqueño colonization.*

ONE of the outstanding developments in the fuel and energy economy of the United States in recent years has been the emergence of natural gas as a contender for markets long dominated by coal and petroleum. For each 42-gallon barrel of crude oil produced in the United States today, the equivalent of an additional 25 gallons comes to the surface as natural gas or its contained liquids.[1] Natural gas now supplies nearly 20 per cent of the nation's commercial energy consumption, compared with less than 4 per cent in 1920, and sales would be significantly higher if existing demands could be met. Only in the last five years, with completion of new long-distance pipe lines from Texas and Louisiana, has it begun to compete with coal and oil for the big Northeastern fuel market. Both net and marketed production of natural gas have more than doubled in less than a decade. Net withdrawals of gas, excepting gas returned to underground reservoirs for cycling and pressure maintenance, amounted to 6.2 trillion cubic feet in 1949 according to preliminary trade estimates.

Natural gas is not only a clean, convenient and economical fuel for domestic and industrial uses but it is also being employed increasingly as a raw material for the manufacture of synthetic organic chemicals and liquid fuels. It is composed almost entirely of hydrocarbons of the paraffin series with its lightest member, methane (CH_4), predominating. Propane and butane, which are gases at ordinary pressures and temperatures, normally are present also. They may be removed and stored in a liquid state under pressure in cylinders. These hydrocarbons are the basis of the "bottled gas" industry and the raw materials for many chemical processes. Pentane and other heavier hydrocarbons which are liquids at atmospheric pressure, also occur in natural gas. When extracted from gas, together with some butanes, they yield "natural gasoline," a product with excellent qualities as a blending agent for motor fuels.

Although natural gas in greater or lesser quantities is found in all oil-producing areas, its use has been negligible outside of the United States except for field operations. While consumption for fuel purposes in this country was 140 billion cubic meters in 1948, the only other countries which produced more than one billion cubic meters for use as fuel were the U.S.S.R., Canada, Romania, and possibly Venezuela.[2] Recent developments, however, indicate a growing awareness of its possibilities. Moscow is now supplied with natural gas by a 530-mile pipe line from Saratov on the lower Volga. Bordeaux, Toulouse, Genoa, Milan,

TABLE I

PER CENT CONTRIBUTION TO TOTAL UNITED STATES ENERGY SUPPLIES OF MINERAL FUELS AND WATER POWER ON A B.T.U. BASIS, 1935–39 AND 1949*

	Average 1935–1939		*1949*[a]	
Petroleum and natural gas				
Natural gas (marketed production)	10.8%		19.1%	
Domestic crude petroleum	31.5		34.3	
Imports, crude petroleum	.8	43.1	3.1	56.5
Coal				
Pennsylvania anthracite	6.2		3.6	
Bituminous coal and lignite	46.9	53.1	34.9	38.5
Water power[b]		3.8		5.0
Grand total		100.0		100.0

*U. S. Bureau of Mines.
[a] Preliminary.
[b] Water power fuel equivalent calculated on basis of average efficiency of fuel-burning central electric stations for years in question.

Turin, and Venice are other European cities now or soon to be connected with local gas fields. In Latin America, a 1055-mile, 10-inch line has been completed from the Comodoro Rivadavia field in southern Argentina to Buenos Aires. Mexico has some production but was still importing more than half of its total consumption from Texas and New Mexico in early 1949.

NATURAL GAS RESERVES

The time may not be far distant when production of natural gas and its contained liquids in the United States will be more important than production of oil. Since the American Gas Association began making its annual estimates in 1946, the trend of natural gas reserves has been conspicuously upwards. Texas has 55 per cent of the total proved reserves; Louisiana an additional 14.8 per cent (see Table II). In 1948 and again in 1949 new discoveries and revisions of existing reserves were more than double the production of natural gas for the year. It is not widely realized that in equivalent heat units the proved and recoverable reserves of natural gas exceed proved petroleum reserves by a substantial margin. Assuming 6000 cubic feet of natural gas as the equivalent of one barrel of oil, with 6,000,000 B.t.u. in each barrel of oil, the estimated natural gas reserves of 180.4 trillion cubic feet on December 31, 1949, were equivalent to 30 billion barrels of oil, or 33.7 billion barrels if its contained natural gas liquids are included. On the same date proved reserves of crude oil were estimated at 24.6 billion barrels.[3] Under the relatively high pressures and temperatures found at great depth, increasing amounts of gas and condensates are being found in relation to oil; and exploration to increasingly greater depths is and must be a characteristic of the continued search for oil and gas.

The westward shift of natural gas production has paralleled that of petroleum. The many small and scattered fields of the Appalachian and Great Lakes states provided the bulk of the nation's requirements until the middle twenties. In 1924 Oklahoma supplanted West Virginia as the leading producing state and five years later was in turn replaced by Texas. Today the Mid-Continent and Gulf Coast areas dominate natural gas production even more completely than they do

TABLE II

NATURAL GAS PRODUCTION AND ESTIMATED PROVED RECOVERABLE RESERVES IN THE UNITED STATES, 1949*

(In millions of cubic feet, at 14.65 lbs. per sq. in. at 60° F)

	Net 1949 Production[a]	*Per cent of U. S. total*	*Proved reserves Dec. 31, 1949*[b]	*Per cent of U. S. total*
Texas	3,023,714	48.4	99,170,403	55.0
Louisiana	805,726	12.9	26,687,811	14.8
Oklahoma	567,333	9.8	11,625,979	6.4
California	543,488	9.3	9,991,635	5.5
Kansas	323,283	5.1	14,089,560	7.8
New Mexico	256,706	4.1	6,241,003	3.5
West Virginia	180,000	2.8	1,715,233	1.0
Kentucky	90,000	1.4	1,349,397	0.7
Wyoming	72,339	1.1	2,173,677	1.2
Pennsylvania	70,000	1.1	621,680	0.4
Mississippi	68,950	1.1	2,528,969	1.4
Arkansas	59,185	0.9	874,190	0.5
All other states	184,315	3.0	3,381,807	1.8
Total, United States	6,245,041	100.0	180,381,344	100.0

*American Gas Association, Committee on Natural Gas Reserves.

[a] Net production equals gross withdrawals less gas injected into underground reservoirs.

[b] Excludes shrinkage caused by natural gas liquids recovery. Proved reserves of recoverable natural gas liquids are estimated at 3729 million U. S. barrels.

the production of crude oil. Texas alone accounted for 48 per cent of the United States production in 1949 and Louisiana and Oklahoma together an additional 23 per cent. Less than one-fifth of the output came from areas outside of the Southwest, chiefly California and the older producing areas of the Northeast.

PIPE LINE DEVELOPMENT

There is only one way to transport natural gas and that is by pipe line. As early as 1891 the feasibility of high-pressure transmission had been demonstrated by a 120-mile pipe line from northern Indiana fields to Chicago, but utilization of gas remained essentially on a local basis until after World War I. Coincident with the great oil and gas discoveries in the Southwest had come important improvements in the design and operation of pipe line and pumping facilities which have continued down to the present day. In modern pipe line operation the gas is usually compressed to 600–800 pounds per square inch. Compressor stations are spaced at intervals of about 200 miles along the lines because gas loses pressure due to friction as it passes through a line and this pressure must be restored by re-compression. The amounts of gas dispatched can be varied by adjusting pressures and if cold weather is predicted in the marketing areas and increased gas consumption for heating expected, the lines are "packed" (pressure built up to higher than normal) in order to meet abnormal load conditions.

By 1930 the first of the long-distance lines from Texas to the industrial centers of the Middle West had been placed in operation. Subsequent developments have been rapid, especially during the past decade. Natural gas pipe lines in the United States, including gathering and transmission lines but excluding local distribution systems, have reached the impressive total of 260,000 miles, more than the point-to-point railroad mileage of the country and two and one-half times the mileage of crude oil pipe lines. Between 1940 and 1948 the volume of interstate transmission of gas by pipe line doubled and by 1952

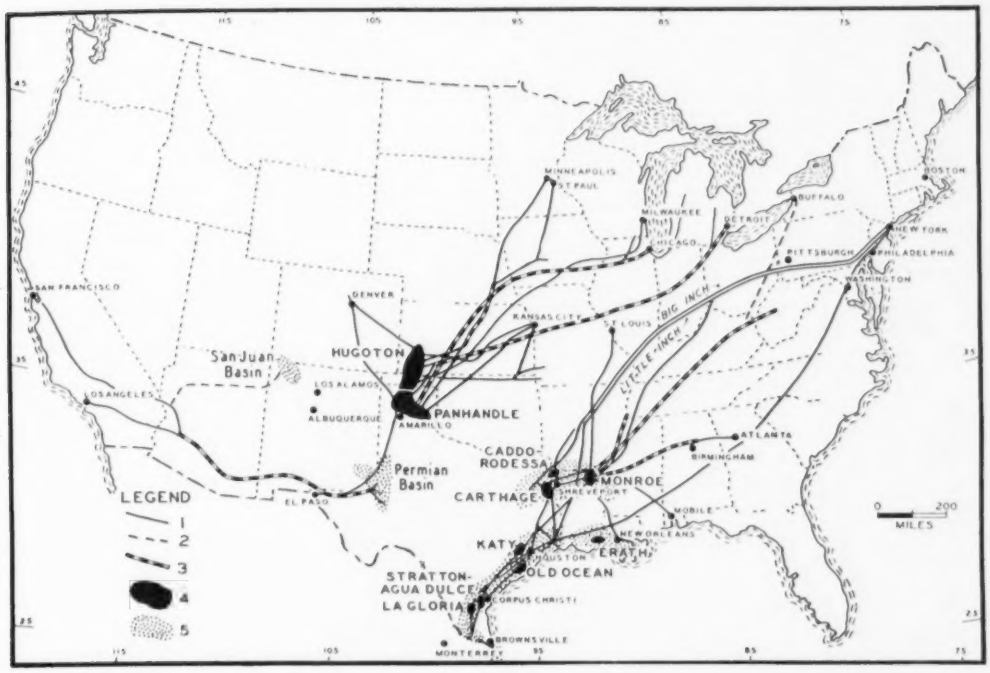

FIG. 1. Major interstate gas pipe lines in the United States, 1949. Legend: 1, pipe lines of 16-inch diameter or more originating in Mid-Continent and Gulf Coast areas; 2, pipe lines proposed or authorized; 3, double pipe lines; 4, principal gas fields; 5, other areas of scattered production supplying major interstate transmission lines.

should have redoubled with completion of the 2.5 billion dollar expansion program now under way.[4] Steel shortages and the difficulty of obtaining the necessary long-term commitments of gas reserves have tended to keep down the number of long-distance projects despite a market clamoring for deliveries. Most important of those currently under construction is the new Transcontinental Gas Pipe Line Company's 1840-mile, 30-inch pipe line from the lower Rio Grande Valley to New York City, scheduled for completion by the fall of 1950. The 200-million-dollar construction job is employing 6000 men and 20,000 freight car loads of steel pipe. The twenty compressor stations along its route will have an initial combined capacity of 209,120 horsepower. Among other things involved are right-of-way permits on more than 7000 separately owned tracts of land.

During the summer months, when fuel demands are slack, gas delivered from the Southwestern fields is stored in partially depleted oil and gas reservoirs in the Appalachian and Great Lakes regions to help ease peak winter demands on utility systems. Long-distance pipe lines are thus allowed a higher year-around load factor and utility companies are better able to adjust deliveries to market demand. Gas in such underground storage at the end of 1949 amounted to 288 billion cubic feet or the equivalent of 4.6 per cent of the net natural gas production during the year. Liquid propone, brought in railroad cars from Texas, has been vaporized and blended with pipe line gas for injection into at least one Michigan storage field to meet emer-

FIG. 2. The open ditch filled with water is indicative of one of the difficulties in building a gas pipe line in Mississippi. Here the fully coated steel pipe is ready for lowering into the trench. The water must be pumped out before the line is lowered. (Photograph by courtesy of Transcontinental Gas Pipe Line Corporation.)

FIG. 3. A cleaning and priming machine applies the first protective coating to a 30-inch welded steel pipe being laid in wooded country in southern Alabama. (Photograph by courtesy of Transcontinental Gas Pipe Line Corporation.)

gency winter demands. The B.t.u. content of this enriched gas was reduced prior to delivery to consumers by mixing with air.[5]

Seventy per cent of the country's proved natural gas reserves occur in "dry" gas fields unassociated with oil. Production of such gas-well gas involves little or no waste, being much more readily adjusted to pipe line demand than is that of gas which occurs either dissolved in or in contact with oil in the reservoir rock. The latter is the so-called casinghead or oil-well gas which has become of increasing importance in the gas supply picture as recovery and conservation techniques have been improved. The bulk of the proved and recoverable natural gas reserves in the United States occur in a relatively few large fields which are predominantly "dry" gas fields. It was estimated in 1947 that 43 per cent of known reserves were located in five Southwestern fields—Panhandle, Hugoton, Carthage, Katy, and Old Ocean.[6]

FIG. 4. This 34-inch gas line in the Panoche Hills southeast of Hollister, California, is being coated with tar and wrapped with a protective coat of felt paper. This is part of the 506-mile, "Super Inch" line being built between Topock, on the Colorado River, and the San Francisco Bay Area. At Topock it will connect with the 1100 miles of main under construction by the El Paso Natural Gas Company to Texas and New Mexico fields. (Photograph by courtesy of Pacific Gas and Electric Company.)

THE TEXAS PANHANDLE FIELD

The most important producing district in the country for more than 20 years has been the Panhandle-Hugoton region, stretching from the panhandles of Texas and Oklahoma to the Arkansas River in southwestern Kansas (see Fig. 7). Its combined reserves may exceed 40 trillion cubic feet or nearly one-fourth of the nation's total. Originally two distinct and non-contiguous fields centering on Borger, Texas, and Hugoton, Kansas, exploratory drilling narrowed the gap between them until recently their boundaries have merged, although structural restrictions probably do not permit free intermingling of the gas. For statistical purposes production from both the northernmost tier of Texas counties and the Oklahoma panhandle is commonly attributed to the Hugoton field.

Production in the Texas Panhandle field in 1949 has been estimated by the State Railroad Commission of Texas at 520 billion cubic feet, which compares with a tentative figure of 415 billion cubic feet for the tri-state Hugoton field (Kansas 221, Oklahoma 118, Texas 76). The Panhandle pay strata, on the flanks of the buried granitic ridge known to geologists as the Amarillo Arch, are at varying depths; in the Hugoton section the average depth of the principal (Permian) producing horizons declines from 3140 feet in the Texas border counties to 2660 feet on the north. Of the five producing horizons in the Panhandle field, the upper three have been correlated with gas-producing horizons of the Hugoton. In both fields original rock pressures were subnormal for gas fields (438–440 pounds per square inch). Reported pressures in

the Hugoton today range from 322 to 435 pounds.[7] The only oil production is along the northern margins of the Panhandle field, especially in the Borger-Pampa area.

Discovery of gas in the Canadian River "breaks" of the Texas Panhandle in 1918 had set off drilling activity which led to the great Borger oil rush of early 1926, but a ready market for the abundant natural gas was at first lacking. To reach the oil-bearing sands the cable drilling tools had first to pass through an overlying gas cap, resulting in tremendous and uncontrolled loss of gas. Natural gasoline and carbon black manufacturers were quick to take advantage of such a situation and within the five-year period from 1926 to 1930 over 50 natural gasoline plants and 24 carbon black plants had been built in the field.[8] The dry, residue gas from the natural gasoline plants continued to be blown to the air after it had been stripped of its liquid hydrocarbons until 1935 when the practice was minimized by legislative action. Waste of gas in the Panhandle field has been incalculable. The peak was reached during 1934 and 1935 when approximately 500 billion cubic feet of gas was stripped and flared each year as compared with an average of 150 billion cubic feet which moved into pipe lines.

The first long-distance high-pressure pipe line from the Texas Panhandle was completed to Denver in 1928 and in the following four years lines were built to most of the major industrial cities of the Middle West. Today seven major transmission companies tap the field, serving markets in Kansas City, Chicago, Detroit, Minneapolis-St. Paul, Denver and Los Angeles. Reserves are for the

FIG. 5 (left). For crossing the Tennessee River a special truck is built to carry the pipe down to the river. Heavy concrete weights have been attached to keep the pipe in place in its underwater bed. This 800-mile, 26-inch line, completed in 1949, runs from the Carthage field to Middletown, Ohio, where it delivers gas to Texas Eastern's "Big Inch" and "Little Inch" systems. (Photograph by courtesy of Texas Gas Transmission Corporation.)

FIG. 6 (right). There are no derricks in Southwestern gas fields. This is a typical "Christmas tree" at a well-head in the Hugoton field near Guymon, Oklahoma. In the background is meter box where gas enters main gathering system.

most part controlled by these companies or their affiliates. Gas has not been encountered in significant quantities in any of the deeper exploratory wells.

Nearly one-third of the Panhandle's production is "sour" gas which contains excessive amounts of sulfur dioxide. Although "sweetening" for pipe line transmission is technically feasible, most of it has been marketed to some 25 carbon black plants which still belch their clouds of black soot over the short-grass plains around Borger and Pampa. Ammonia fertilizer and synthetic rubber plants are other industrial consumers in the area. Helium is extracted from the gas produced from the small Cliffside field north of Amarillo at a government-operated plant.[9] Production of this rare gas in excess of current needs is injected into the underground formation for storage. The stripped residue gas is sold to pipe line companies.

Hugoton Field

The Hugoton field underlies the endless bonanza wheat fields of an area that during the thirties was the heart of the nation's "Dust Bowl." Although much larger in area than the Panhandle its development has been at a slower pace. It was first brought into commercial production in 1927 when a pipe line was completed from the grain-elevator town of Hugoton to Garden City, Kansas. Most of the long-distance transmission companies which carry Panhandle gas are also active in the Hugoton area and gas from the two fields is blended and brought to a uniform heat value in large gathering and compressor stations such as those to be seen near Liberal, Kansas. Development of the field is still in progress. During 1949 new pipe lines from the Hugoton field to Kansas City and to Wisconsin and Michigan markets were opened. Industrial utilization of this gas has been limited to a handful of carbon black and natural gasoline plants centering around Ulysses, Kansas, and Guymon, Oklahoma. At the former place a "hydrocol" plant for the manufacture of gasoline and chemical by-products from natural gas by a modified Fischer-Tropsch process was dedicated in 1949, but the higher returns promised from sales to pipe line outlets may discourage other such investments.

Louisiana's Monroe Field

Commercial development of the Monroe field of northern Louisiana antedates that of Panhandle-Hugoton by nearly a decade. The first gas well was brought in on Christmas Day, 1916, and by the next year pipe line connections with the city of Monroe had been installed. Alexandria was linked to the field in 1923, and Shreveport and New Orleans four years later. Shreveport, however, had been on gas as early as 1906, when a line had been run to it from the flush Caddo oil and gas field in the extreme northwest corner of the state. It was the carbon black industry that played a particularly important role in the early history of the Monroe field. From 1920 to 1928 Louisiana was the country's leading carbon black producing state. As early as 1923 there were 35 carbon black plants in the Monroe area. Gas withdrawals reached their peak in 1936, production in that year reaching 209 billion cubic feet compared to an estimated 154 billion cubic feet in 1949, but the number of wells has continued to increase and is now over 1500. With acid treatment of the gas-bearing Monroe limestone (Cretaceous) helping to sustain production in the face of declining pressures, reserves are estimated at close to two trillion cubic feet or approximately two-fifths of the volume of the field's total past production. Although the carbon black industry has since

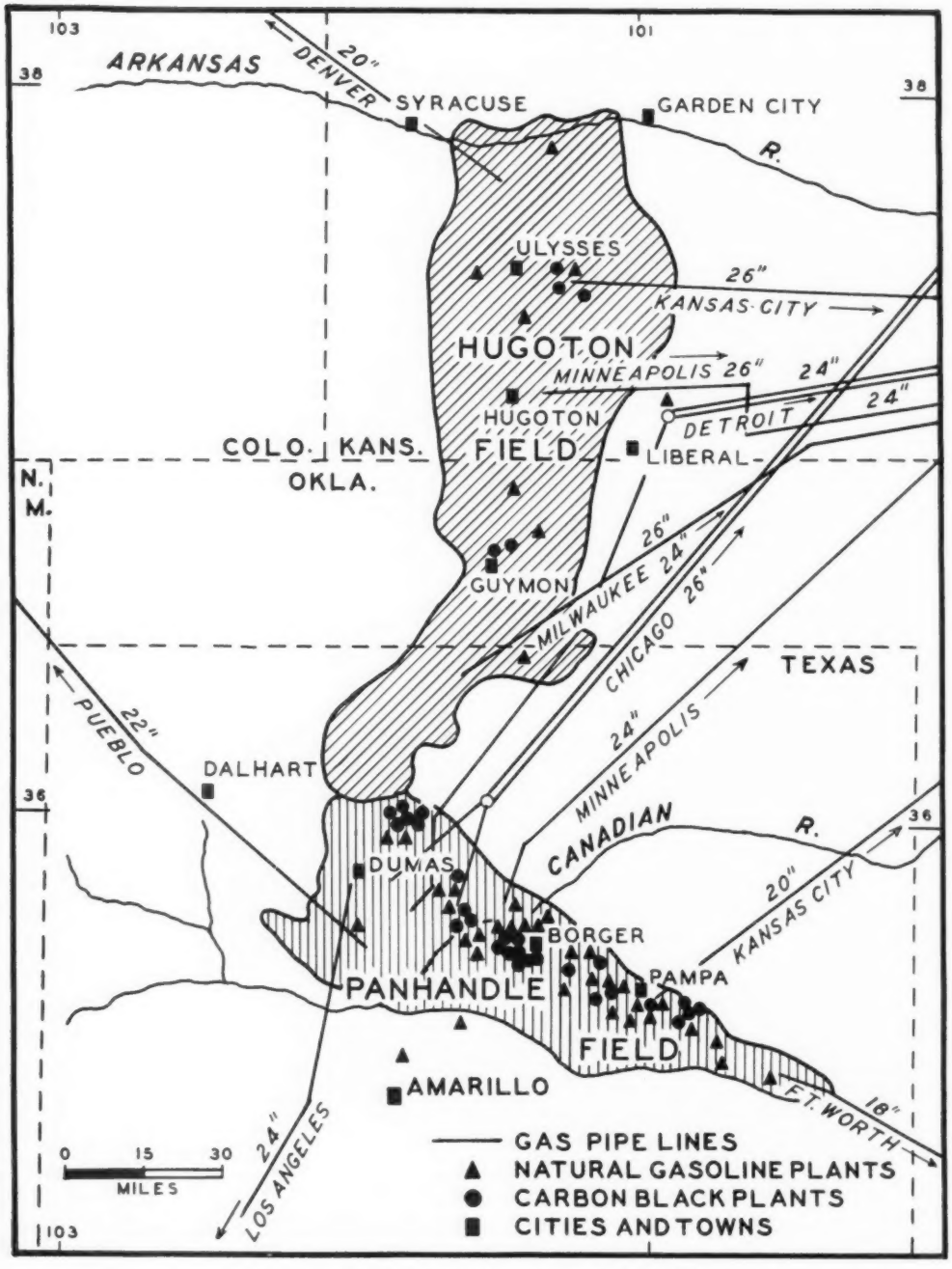

FIG. 7. Panhandle and Hugoton gas fields, 1949.

moved on to the newer Texas fields (there are four plants remaining in the Monroe area) major pipe line markets still supplied primarily from this field include St. Louis, Memphis, Atlanta, Birmingham, and Mobile. The newer transcontinental lines which pass through or near the field take little or no gas from it.

The Richland field, discovered in

1926 southeast of Monroe and which rivaled the latter in production for a few years during the early thirties, is now depleted.

THE NEW CARTHAGE FIELD

Situated in the piney woods along the Texas-Louisiana boundary, the Carthage gas field of Panola County, Texas, has joined the first rank of producers only during the past three years. It is one of the major supply sources for the government-built "Big Inch" pipe line, one of two constructed as an emergency measure to carry East Texas and Gulf Coast crude oil to Eastern refineries and since converted to natural gas transmission. Of the 536 wells that were producing in the Carthage field in April, 1949, all but 25 had been completed since 1944. Production, which reached 238 billion cubic feet in 1949 and is still climbing, is from four different lower Cretaceous sands, at depths of from 5000 to 6000 feet. The gas is virtually all sold to pipe line outlets after processing for liquid hydrocarbons.

GULF COAST FIELDS

Although gas reserves under the Gulf Coast of Texas and Louisiana may represent as much as one-third of the nation's total, they are dispersed among a multiplicity of smaller fields. In 1948 production of gas-well gas was reported from 741 separate fields in the Gulf Coast provinces of Texas and Louisiana, some fields supporting production from as many as 20 separate horizons and to depths of 12,000 feet. Largest producers were Houston's Katy field and the Stratton-Agua Dulce and La Gloria fields south of Corpus Christi. In Louisiana, where half of the state's production and 70 per cent of reserves are now in the southern parishes, extensive new discoveries have recently been made on state-owned coastal marshlands south and west of New Orleans. Offshore exploration on the so-called "tidelands" promises important additional discoveries. By the end of 1949 eleven gas or gas-condensate fields had been discovered off the Louisiana coast, but because there was no way to get the gas or its liquid content ashore they were all "shut in." No commercial discoveries had yet been made off the Texas coast, but drilling was in progress.

Out-of-state transmission from this area began in 1944 with completion of Tennessee Gas Transmission Corporation's 1265-mile line from near Corpus Christi to West Virginia; the line was later "looped" or doubled. Later the government-built "Little Inch" tapped the coastal fields. By the end of 1949 Transcontinental's line to New York City was nearing completion while Tennessee Gas Transmission had obtained authorization to extend its system to Buffalo, New York, and to increase its capacity to over one billion cubic feet daily. Applications were on file for extension of service into the big New England market area by each of the three major systems authorized to serve the East Coast. Thus far Gulf Coast gas has been dedicated primarily to the expanding markets in the states along the Atlantic seaboard from the Carolinas to New England, leaving the Middle West to be served from the Hugoton-Panhandle area. In late 1949, however, an application was filed with the Federal Power Commission for construction of a 1254-mile, 30-inch main line from the Texas Gulf Coast to the Chicago area by the Texas-Illinois Natural Gas Pipeline Company, a subsidiary of People's Gas, Light and Coke. Gas reserves already committed to the project were claimed sufficient to permit delivery of 538 million cubic feet daily for a minimum of 20 years, chiefly in the La Gloria and Old Ocean

FIG. 8. This combined compressor station and natural gasoline plant near Liberal, Kansas, processes 500 million cubic feet of gas daily from the Hugoton and Panhandle gas fields. Gas is started on its way to Detroit by 15 giant engines of 20,600 horsepower capacity.

FIG. 9. Carthage Corporation's new natural gasoline plant on the Carthage gas field, Texas. Liquid hydrocarbons are extracted here from gas produced from the Carthage field.

FIG. 10. This new carbon black plant in the midst of the wheat fields of Southwestern Kansas uses Hugoton natural gas as its only raw material.

fields. Another separate application proposes a 740-mile, 26-inch line from southern Louisiana to central Illinois to supplement supplies of Hugoton and Panhandle gas moving to Indianapolis and Detroit area markets.

Industrial utilization of gas, both as a raw material and as a fuel, has probably reached its greatest development on the Gulf Coast. The chemical processing of paraffin gases which occur both in natural gas and refinery gases has enjoyed a phenomenal growth here as a result of the war and post-war boom. This new synthetic organic chemicals industry which has sprung up between Baton Rouge and Brownsville is dependent largely on large quantities of low-cost methane, propane, and butane, the principal constituents of natural gas.[10]

CASINGHEAD GAS CONSERVATION PROGRAMS

Casinghead gas, as a by-product of oil field operations, was long considered a dangerous nuisance that could only be flared or vented to the air. Where operations were geared to crude oil output the salvaging and marketing of the gas was both inconvenient and costly. Not only is casinghead gas production not readily adjusted to market demand but, coming to the surface under low pressure, the gas must be considerably compressed for pipe line transmission. Its utilization awaited development of high-pressure gas-oil separators and the improvement of other surface recovery and compressing equipment.

In the great bonanza oil fields of the Southwest and California there was profligate waste of such gas and consequent rapid declines in field pressure during the early production period. Perhaps with no other natural resource has waste been so great. It has been estimated that, during the period 1922–1930, waste of natural gas approximated 30 per cent of the total volume consumed in the United States and that the average waste may have been some 1.25 billion cubic feet per day.[11] The flush production and rapid decline of such important Southwestern fields as Caddo, Desdemona, Smackover, El Dorado, Rodessa, and Oklahoma City as well as many of the fields in the Los Angeles Basin of California are directly attributable to this cause.[12]

A growing realization of the role of gas in the expulsion or replacement of oil from the reservoir rock, together with vigorous "casinghead gas conservation" programs promoted by state regulatory bodies, has led to great improvement in the situation in recent years. Networks of gas-gathering lines are being extended into oil fields while unmarketed gas is being returned to the reservoir.

Casinghead gas conservation is being pushed with special vigor in the state of Texas, where it constitutes close to one-third of all gas withdrawals. According to the Texas Gas Conservation Engineering Committee, the flaring of gas at casinghead gas plants had been reduced from 325 to 47 million cubic feet daily from March 1945 to March 1949, despite a much greater throughput at the latter date. Today more than 55,000 oil wells in Texas are connected with casinghead gas intake plants. The Railroad Commission has been ordering the shut-down of some oil fields where unnecessary waste of gas incident to oil production continues. Flaring is permitted only where fields are either so small or so isolated that neither re-injection nor construction of pipe line outlets is economical.

Substantially all gas produced today, except that vented or used in field operations, is stripped of its liquid

fractions in natural gasoline or cycling plants and the output of such plants is becoming an important factor in the total supply of liquid fuels. In many cases the cost of gathering casinghead gas for use as a fuel would be prohibitive were it not for the recovery of its butane, propane, and natural gasoline fractions for which an expanding and profitable market exists. The stripped or residue gas from these plants, if not sold, is compressed and injected into the underground reservoir for later marketing. This operation, first carried out successfully in Texas in 1938 and three years later in Louisiana, is known as "cycling." Today about one-fourth of the gas produced in Texas is returned to the formation in such cycling or pressure maintenance operations. The usual goal is to provide gas drive for oil production, but in certain rich condensate fields where lowering reservoir pressures may lead to the "retrograde condensation" of the heavier, vapor-phase hydrocarbons into liquids, recycling may be necessary to maintain pressures until most of the heavier hydrocarbons have been stripped from the reservoir. In Texas alone some 128 natural gasoline and cycling plants are reported to have been under construction or completed since the end of the war at a cost of 256 million dollars. The plants are commonly co-operative ventures, operated by either major or independent oil companies, which serve all the producers in one or more fields. Largest of these gas-processing plants are in the Katy, Agua Dulce, Old Ocean, and Panhandle fields.

The Permian Basin

Casinghead gas accounts for the larger part of natural gas production in parts of Oklahoma, in California, and in the so-called Permian Basin of West Texas and southeastern New Mexico. In the first two areas production is locally marketed, but the Permian Basin has recently become a major gas exporting area. Principal markets for its gas had been the copper smelters of New Mexico, Arizona, and Sonora until completion of a pipe line to Southern California in late 1947. In authorizing exports to the West Coast, the Federal Power Commission called attention to the fact that larger quantities of oil-well gas in the Permian Basin were currently being wasted for lack of a market and indicated that this was an important factor in warranting approval of the venture.[13] Deliveries of Texas and New Mexico gas to the West Coast are to be upped to a maximum of 925 million cubic feet daily by 1952 with completion of a second, 34-inch ("Super Inch") pipe line, now under construction, to serve the San Francisco Bay Area. In recognition of the difficulties inherent in obtaining a long and continued supply of gas from oil fields, the gathering system was extended to the Panhandle gas field in late 1948. It is proposed to obtain additional "dry" gas supplies from the San Juan Basin of northwestern New Mexico which currently serves Albuquerque, Santa Fe, and the Atomic Energy Commission's installations at Los Alamos, New Mexico. The newly discovered Scurry County Reef oil field in West Texas, which by early 1950 had begun to look like "the biggest thing since East Texas," now looms as yet another potential source of casinghead gas for the lines to the West Coast.

Too Many Pipe Lines?

The rapid expansion of high-pressure pipe lines carrying away the Gulf South's "limited and irreplaceable" supplies of natural gas has led to a growing concern within the area as to the wisdom of such unrestricted "ex-

ports," especially to areas with adequate coal or water power reserves. In 1949 there were 17 such major interstate pipe lines with an annual capacity of over one trillion cubic feet carrying gas from Texas alone to more than 30 states. Texas natural gas exports, which doubled between 1947 and 1948, would approach 2.5 trillion cubic feet by 1952 if all contemplated interstate pipe line projects were completed.[14]

Notwithstanding constitutional limitations on interstate barriers to trade, there has been a rising crescendo of protests against the granting of new permits for additional pipe lines, at least until the future needs of the producing areas have been given full consideration. The industrial developments of the Gulf South is in considerable measure dependent on the long-term availability of large quantities of low-cost gas. Increasing exports to the Northeastern Industrial Belt can only mean a shortened life expectancy for Southwestern reserves. On the other hand it has been suggested that, since gasification of coal may one day provide a satisfactory and economical substitute for natural gas, the natural gas states may do well to "cash in" before cheap, 1000-B.t.u. manufactured gas starts moving back from the Appalachian coal fields to Texas and Louisiana. But, as FPC Commissioners Olds and Draper have stated it, "even if natural gas is completely replaceable by synthetic gas from coal, it cannot be made available to the Southwest without a transport differential which is now in its favor. The result of depletion of the main fuel reserve of the Southwest through syphoning its natural gas to the Northeast will be to remove the main basis for the hopes for industrial decentralization."[15]

GOVERNMENT REGULATION

The Federal Power Commission's rate-regulating authority, under the Natural Gas Act of 1938, has led to long and bitter controversy between the industry and Government. Producers argue that this admittedly superior fuel is today grossly underpriced at the well-head. Unlike coal or petroleum, it is a commodity for which the cost of transport to market, including pipe line investment, is normally much greater than the cost of production. Although the average field price stipulated in new natural gas contracts increased nearly fourfold between 1941 and 1949 in the Southwest, even at eight to ten cents per thousand cubic feet natural gas is still priced far below other fuels on an energy-content basis. In May, 1949, for example, William J. Murray, Jr., Chairman of the Railroad Commission of Texas, calculated that, at a well-head price of five cents for natural gas, equivalent heat content prices would have been 30 cents per barrel for oil and $1.25 per ton for coal. Even after transportation charges have been met for pipe line transmission half way across the continent natural gas commonly retains a competitive price advantage over both coal and oil. It is maintained that low field prices are discouraging active exploration and development programs for natural gas and have rendered many casinghead conservation projects economically unattractive. Many producers and leaseholders have been pressing for replacement of FPC control over field prices by a "fair field price" formula which would appear to permit charging whatever the market will bear. In practice, FPC's price-fixing activities have been restricted to production from properties owned by interstate transmission companies and their affiliates. These

companies, however, are now said to produce about 40 per cent of the gas they transmit; in the Panhandle they control two-thirds of all reserves. State regulatory bodies have entered the gas price controversy in Kansas and Oklahoma by instituting minimum field prices for natural gas. These were still being contested in the courts in early 1950. Suggestions for establishing minimum field prices have become increasingly common among Texas and Louisiana producers. Present prices paid to independent producers vary widely at present depending on the number and nearness of pipe line outlets and the date of the particular gas purchase contract.

Major oil companies, which control much natural gas production and reserves as a natural by-product of their primary activities, have sometimes been reluctant to sell gas to interstate pipe lines, professedly through fear of thus being placed under FPC jurisdiction as natural gas utilities. Their alternatives are to sell to local consumers or to cycle the stripped gas back into the formation. In California, where casinghead gas provides the largest share of local gas production, the major oil companies have been under fire from consumers for diverting increasing amounts of oil-well gas to field repressuring and pressure maintenance operations at the very time when demand is increasing sharply, thus forcing imports of New Mexico and Texas gas at significantly higher prices. Yet such re-injection serves not only to increase ultimate oil recovery but permits the storage of large amounts of gas for future and probably more lucrative marketing. Both conservation and the profit motive appear thus to be served.

In all natural gas producing areas, field proration and unitization programs, usually administered by state control bodies, are becoming increasingly numerous as evidence accrues that maximum yields are not compatible with rapid, town-lot developments.

CARBON BLACK MANUFACTURING

One of the most controversial elements in the natural gas conservation question has been the carbon black industry. Most carbon black, a primary ingredient of automobile tires and printing inks, is manufactured by the incomplete combustion of natural gas. The carbon is precipitated from a gas flame thrown against a moving band of steel. In the past carbon black has been a "scavenger industry," using very low-cost natural gas not otherwise marketable. Its early development in the Southwest was in the great Monroe and Panhandle fields. By the early thirties production in West Virginia, the early center, had entirely ceased. In 1949 there were 42 plants operating in Texas of which more than half were in the Panhandle. Eight plants remained in Louisiana and a scattered few in Kansas, Oklahoma, and New Mexico.

The increased quantities of gas being cycled, together with the intensified competition from transmission lines and other industrial consumers for natural gas reserves has "put the squeeze" on the carbon black industry since the war. Having reached its last geographical frontier, so to speak, it must expect both to pay higher prices for its raw material and to increase its efficiency markedly if it is to maintain its monopoly of most of the world's carbon black markets. All carbon black manufacturing processes are very dirty in that they produce a great deal of smoke. They are also very wasteful for, although 1000 cubic feet of methane gas actually contains 33 pounds of carbon, the actual yield of carbon black

from the common "channel" process is usually less than two pounds. Other processes, though more efficient, do not produce a product of the same velvety black appearance and quality.

THE FUTURE OF NATURAL GAS

It seems apparent that future market demands for natural gas in the United States cannot be met. Recent discoveries in Alberta, Canada, have suggested additional future sources of natural gas; in the spring of 1950 action was still being deferred by Canadian officials on all requests for pipe line permits for lines to both the Pacific Northwest and the Chicago area. The demand for natural gas has been described as "insatiable, incalculable and, in all likelihood, unsuppliable." The reserves-to-production ratios—28.9 for natural gas in 1949 compared to 13.6 for petroleum—suggests that it is being consumed at less than half the rate of domestic petroleum reserves; but in the long run discoveries cannot be expected to keep pace with a sharply rising consumption. Only in the past few years have coal and fuel oil sales in the densely populated and industrialized Northeast begun to feel the impact of the new competition from natural gas. Eastern utility companies have estimated that, taking into account the relative heat content of the two gases, natural gas may enter the distribution lines at as little as one-fourth the cost of conventional manufactured gas. Trade estimates in early 1950 indicated that approximately 80 utility companies now distributing manufactured gas in the Middle Atlantic and New England states will take natural gas in whatever quantities it is allotted from the transmission systems as soon as it becomes available. Some plan to go onto straight natural gas, others to use it for enriching the manufactured product. It may be indicative of the trend that while marketed production of natural gas increased 12 per cent in 1949 over the preceding year, crude oil output declined 8 per cent and coal production declined 28 per cent.

The convenience and flexibility of natural gas should continue to make it the preferred household fuel, but its utilization by industry will depend on its price relationships with competitive fuels and raw materials. It is especially the Gulf South, lacking significant coal and water power reserves, where natural gas, together with oil, is playing a crucial role in regional economic development. The future of this vigorous new industrial frontier is vitally dependent on the petroleum industry's ability to maintain its excellent production and discovery record for these preferred fossil fuels.

REFERENCES CITED

1. *Oil and Gas Journal* (Tulsa), Vol. 48, No. 30, December 1, 1949.

2. United Nations, Dept. of Economic Affairs, *World Economic Report*, 1948, Lake Success, June, 1949, p. 12.

3. American Gas Association and the American Petroleum Institute, "Proved Reserves of Crude Oil, Natural Gas Liquids and Natural Gas, December 31, 1949," New York, 1950.

4. "Natural Gas—Whoosh!", *Fortune*, Vol. 40, No. 6, December, 1949.

5. *Gas* (Los Angeles), September, 1948, p. 74.

6. Federal Power Commission, "Natural Gas Investigation" (Docket, No. G-580), Report of Commissioner Nelson Lee Smith and Commissioner Harrington Wimberley, Washington, 1948, p. 40.

7. "World's Largest Gas Field is Amazing Development," *Oil and Gas Journal*, Vol. 47, No. 36, January 6, 1949, p. 84.

8. C. A. Warner, "Texas Oil and Gas Since 1543," Houston, 1939, p. 269.

9. R. A. Cattell, "Helium—the Wonder Gas," *Scientific Monthly*, Vol. 69, 1949, pp. 222–228.

10. James J. Parsons, "Recent Industrial Development in the Gulf South," *Geographical Review*, Vol. 40, 1950, pp. 67–83.

11. National Resources Committee, "Energy Resources and National Policy," House Doc. 160, 76th Congress, 2nd Session, January, 1939, p. 188.

12. Carl Coke Rister, "Oil! Titan of the Southwest," Univ. of Oklahoma Press, Norman, 1949.

13. "Western Power and Fuel Outlook—II. Natural Gas," *Monthly Review*, Federal Reserve Bank of San Francisco, May, 1949, pp. 52–61.

14. Stuart McGregor, "What Shall Texas Do About Natural Gas?" *The Texas Geographic Magazine* (Dallas), Vol. 13, Spring, 1949, pp. 1–4.

15. Federal Power Commission, "Natural Gas Investigation" (Docket No. G-580), Report of Commissioner Leland Olds and Commissioner Claude L. Draper, Washington, 1948, p. 7; "Curbing Texas Gas Exports is Unsound Proposal," *World Oil* (Houston), Vol. 130, No. 1, January, 1950, p. 40 ff.

UNITED STATES INFLUENCES ON THE AGRICULTURE OF PRINCE EDWARD COUNTY, ONTARIO

Ernest Dix

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PRINCE EDWARD COUNTY is located on the north shore of Lake Ontario about 100 miles northeast of Toronto. Rochester, New York, is 60 miles across the lake due south of the western end of the county; Oswego, N. Y., is less than 40 miles southeast from the nearest land in the county, Point Traverse.

The county is a geographic as well as a political unit; it is a peninsula tied, on its western end, to the mainland by an isthmus only one and one-half miles wide. The Bay of Quinte, a narrow body of water varying from one-half mile to two miles in width, separates the peninsula from the mainland to the north. Yet the county is by no means isolated; one may enter by road along the isthmus by a bridge across the Bay of Quinte, or by one of three ferries.

The area of Prince Edward County is 390 square miles, approximately the same as that of Montgomery, one of New York State's smaller counties. Prince Edward is irregular in shape for a large number of coves and bays increase the length of shore line to about 300 miles, three times the mileage it would possess were the shore line straight. The peninsula has a maximum length of 38 miles and a maximum width of 15 miles; yet its outline is indented so that no point is more than five miles from either the Bay or Lake.

This area, a gently rolling lacustrine plain occasionally interrupted by abrupt cuestaform escarpments, has been essentially agricultural since its permanent settlement in 1783. Nevertheless, the pattern of land utilization has changed considerably at several stages in the period from settlement to the present. The underlying reasons for many of these changes are not so much matters of the geographic or economic nature of the area itself or even of the Dominion of Canada, but rather events and influences of an economic nature in the United States, particularly in New York State. The agricultural pattern and life of the people of Prince Edward County from 1860 to 1890 were closely tied to economic factors south of the border. This paper is primarily concerned with this period from 1860 to 1890, a period in Prince Edward agriculture still referred to by natives of the county as the "Barley Days."

After the initial permanent settlement of the county in 1783, the transition from pristine wilderness to farming community proceeded rapidly. Clearing and pioneering can be considered to have been essentially completed by 1835. The population numbered approximately

12,000 by that date. Thus in 50 years from the beginning of settlement the county had acquired three-fourths of its present total. Until 1835, the farmers of the county, for the most part, practised subsistence agriculture. Then, they became aware of, and responsive to, overseas and United States markets for certain agricultural products. New York State was at this time the leading barley producer in the United States; a growing malting industry had developed around this production. Prince Edward County was primarily a wheat producer. A small amount of barley was grown, a barley with superior malting qualities, very desirable for brewing purposes. In 1851, barley acreage was the lowest among the grains—about one-third that of corn, one-fourth that of rye, and only one-twelfth that of wheat. It occupied only two and one-half per cent of the total cultivated acreage. Ten years later, in 1861, barley acreage was over half that of rye, approximately equal to that of wheat, and greater than the acreage of any other grain. It occupied nearly 11 per cent of the total cultivated acreage, an increase shown on the line graph (Fig. 1). Shortly thereafter barley became the dominant grain in Prince Edward agriculture, a role it was to play until 1890.

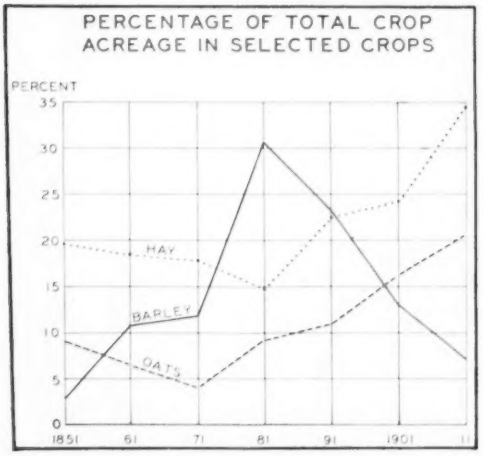

FIG. 1.—Changes in the proportion of total crop acreage of Prince Edward County devoted to barley, hay, and oats, 1851 to 1911.

The American Civil War and events connected with it were the stimuli from south of the Lakes which accelerated this change in agriculture. The United States Internal Revenue Tax on whiskey was raised from 25 cents per gallon to two dollars per gallon. This tax was rapidly reflected in increased consumption of beer, an increase which one historian places as high as sixteenfold in the five year period 1860 to 1865. The American brewers, who believed Canadian barley produced superior beer, purchased increasingly large quantities of that grain from across the Lakes. Toronto shipped four times as much barley in 1865 as in 1860. Robert L. Jones says that as early as 1863 New York farmers were losing control of their own market for barley. He states that Albany, the market for most of the Canadian barley, received 80 per cent of her barley from Canadian farmers in 1862.

In 1871 and 1881 statistics for barley production in Prince Edward County are available in bushels but not in acres. However, if the yield per acre was average, barley in 1881 was grown on over 40,000 acres, not only occupying far more land than any other grain or crop but also occupying nearly one-third of the total cultivated land of the peninsula. The relative unimportance of dairying during this same period can be gauged by noting that, in 1881, hay acreage was less than half that of barley. In that same year, barley was grown on more acres than were used in 1945 for all grains.

The "Barley Days" were busy and prosperous ones for the county. Storehouses and wharves were erected all along the shores of both the Bay of Quinte and Lake Ontario. Small sailing vessels called several times weekly dur-

ing the fall shipping season to load and carry tons of the grain to the United States, especially to Oswego. When a vessel made port, the farmers were immediately notified and, no matter what the hour of day or night, barley at once started toward the loading stations. Many of the vessels were built in county shipyards, and were skippered by county men.

In 1890, the "Barley Days" came to an abrupt close. The markets in the United States which had called the trade into being were effectively shut off. On October 6, 1890, the United States Congress passed the McKinley Tariff, a bill which placed a tax of 30 cents per bushel on imported barley. The tariff not only closed United States markets to Prince Edward farmers; it did more—it closed to New York State brewers the source of much of their high quality barley. According to John C. Weaver, the collapse of the malting industry in New York at about the close of the century was in part due to the tariff. The largest share of the malting industry, as well as the barley production, moved westward to Wisconsin, Iowa, Minnesota, and Illinois. New York production declined from a harvest of over eight million bushels of barley in 1889, to one of less than two million bushels twenty years later.

The effect of the McKinley Tariff on the agriculture of Prince Edward County, geared as it was to export crops and especially to barley can be imagined. The next few years were lean years. By 1901, barley acreage had declined to about one-third the 1881 high; the yield was the lowest for a census year since 1861. For the first time since the 1850's more land was used for oats than for barley. Nearly twice as much land was used for hay as for barley, a fact which indicates the increasing importance of the dairy industry. The bar graph shows the comparative yields of various grains for 1881 and 1901 (Fig. 2). While barley production tumbled from nearly 900,000 bushels to about 260,000 bushels, most of the other grains showed marked increases, with the exception of rye which remained about the same. Wheat production increased by 120 per cent and oats showed a 30 per cent gain; even corn showed a gain of 10 per cent.

The McKinley Tariff, by effectively ending the barley era of Prince Edward agriculture, indirectly provided the impetus for changing the agricultural pattern so that the void left by the loss of United States markets was ultimately filled. Factory canning of fruits and vegetables was just beginning to become important. In 1901, vegetables and small fruits were produced on relatively few acres, between two and three thousand, yet the county was one of the leading vegetable packing counties in Ontario. From 1910 to 1930, the canning crop acreage increased sevenfold; the growing of tomatoes, corn, and peas for canning became one of the

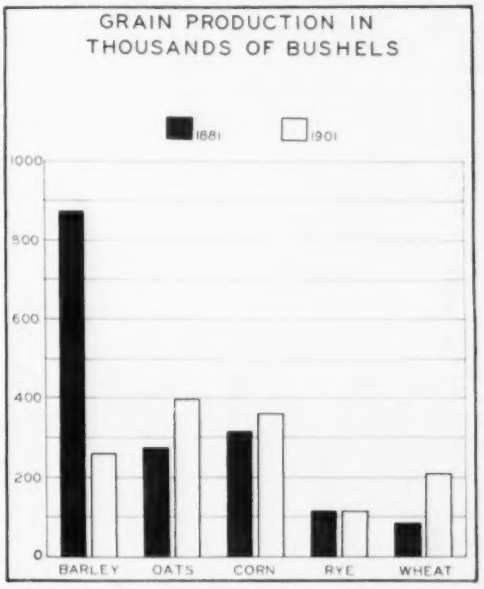

FIG. 2.—Production of the principal grains in Prince Edward County, 1881 contrasted with 1911.

leading agricultural activities in the new pattern. Dairying, always important, but hitherto overshadowed by barley and other cash crops, was also stimulated. As can be seen in the line graph (Fig. 1), the percentage of total crop acreage in hay rose steadily from less than 15 per cent in 1881 to nearly 25 per cent in 1901, and to nearly 40 per cent in 1921. The number of milk cows per person, another indication of relative importance of dairying, rose from 0.52 in 1881 to 0.78 in 1901. Most of the milk was used for the production of butter and cheese. Canadian or Empire markets were served rather than those of the United States, both in dairy and cannery products.

The reorientation of Prince Edward County agriculture from barley and other crops for American markets to canning crops and dairy products for domestic and Empire markets cannot be attributed entirely to the McKinley Tariff. Barley growing by farmers of the county and of New York State would almost certainly have declined as western centers of barley production expanded. The peninsula would probably have grown increasing acreages of canning crops as the market for canned vegetables and fruits expanded. Nevertheless, the tariff did set the date for the reorientation and probably is responsible for the rapidity with which it was accomplished.

INDUSTRIAL DEVELOPMENT IN EAST BENGAL (EAST PAKISTAN)

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EACH region has peculiarities of its own which are related to its geographic personality. East Bengal is unique for its problems in the economic, social, and demographic spheres. With an area of only 54,151 square miles and, at present, a population of roughly 46 million, it has an average density of about 850 persons per square mile. The province presents a peculiar demographic picture in the structure, pattern, and distribution of its teeming millions. In several districts—i.e., Tippera, Dacca, Noakhali, and Faridpur—the density is well over 1000 per square mile. In several smaller tracts densities over 2000 are met with. The Munshiganj Subdivision in Dacca district has a density of 2596, and perhaps the highest rural density in the world is reached in Lohajang thana in Dacca district with 3228 to the square mile. Thus East Bengal is one of the most closely packed areas of its size in the world.

In its economic characteristics the province is equally remarkable. It has vast agricultural resources, including about 78 per cent of the world's crop of jute the export of which brought nearly Rs. 109.6 crores (about 30 million dollars) in 1948. The province is among the greatest producers of hides and skins in the world and is also, at present, the third largest producer of tea, with 45 million pounds of annual output. Paddy is intensely cultivated on every available acre of land, and forests occupy 18 per cent of the surface. But mineral exploitation is next to nil at present, and no power resources have thus far been developed.

In addition, there is a legacy of industrial backwardness, dating from the dawn of the modern industrial era in British Bengal. The late Qaid-i-Azam Muhammad Ali Jinnah, founder of Pakistan, truly said that East Bengal throughout these generations served merely as a hinterland for building up the wealth and prosperity of Calcutta. With all its immense agricultural resources and vast multitudes, the province was insignificantly developed industrially. The Calcutta-Howrah-Hooghly region and other parts of 24 Parganas district had about 57 per cent of the factory establishments and more than 82 per cent of the workers employed in industry in Bengal in 1939, only eight years before the establishment of Pakistan.[1] Therefore, in 1947, the Pakistan province of East Bengal inherited only nine cotton factories out of 400 in India,

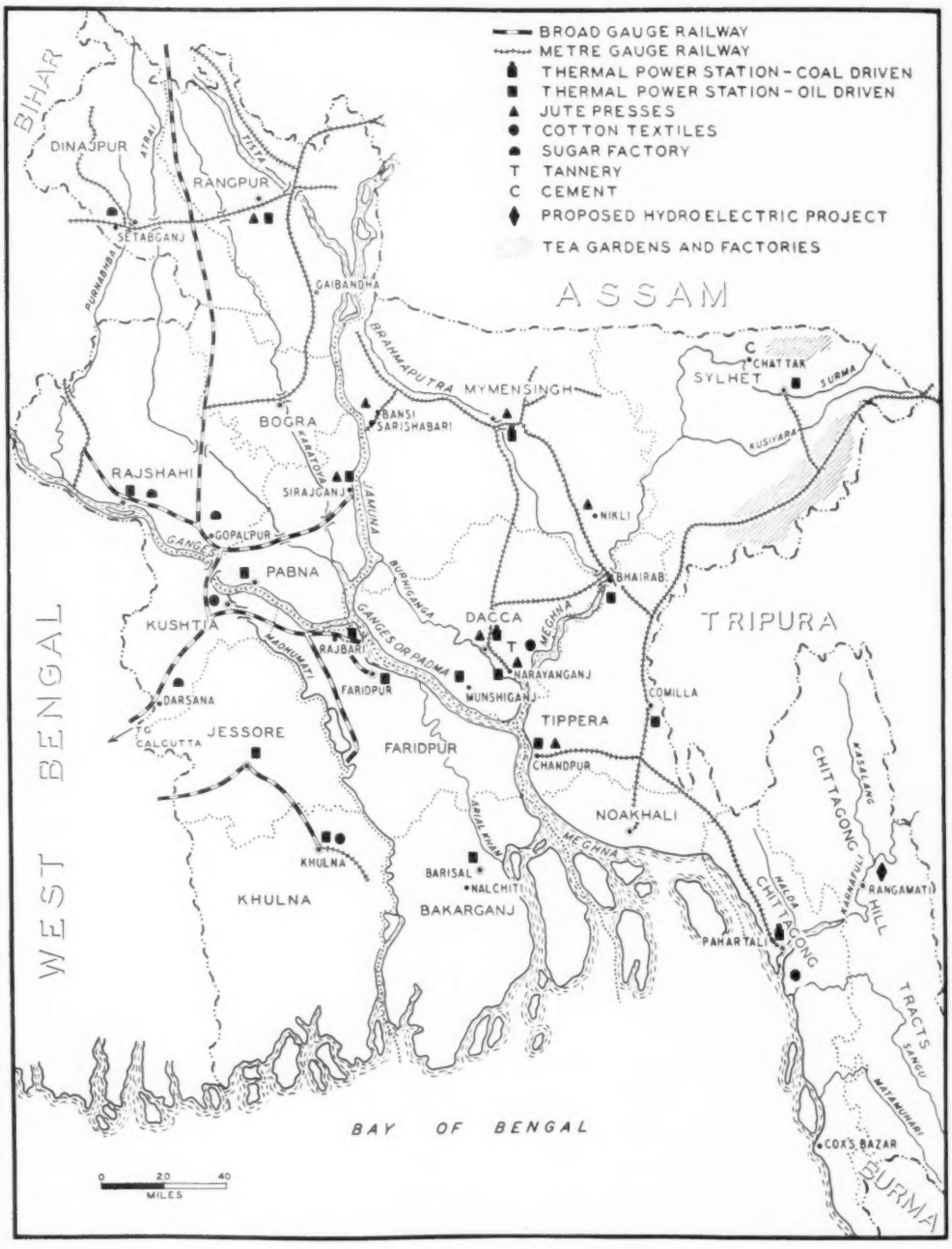

FIG. 1. Industrial map of East Pakistan.

none of India's 106 jute mills, and not a single iron and steel plant, coal mine, or established hydroelectric project. It was left with 50 jute baling presses of all types, 58 rice mills of all descriptions, three sugar factories, two small oil mills, two tiny glass works, and one cement factory. That is more or less the picture obtaining even today.

This industrial backwardness with

all the staggering handicaps it represents provides only one consolation: the escape from the evils of excessive concentration of industry with its jerry-built urban agglomerations. Indeed, an advantage lies in the fact that a start has to be made from scratch. This fact often invites the perplexing appellation, "East Bengal—a planner's paradise."

Let us examine a little further the anatomy of this meager industrial development, to appreciate more fully the need for a rational industrial planning.

JUTE

It is proper to begin with jute, since this is East Bengal's major cash crop and chief means of obtaining capital goods from the outside world.

The total yield of jute constitutes normally about 78 per cent of the world crop.[2] This year's yield was in the neighborhood of 5½ million bales (of 400 pounds each) on an acreage of about 1.9 million. The 1947–48 yield amounted to nearly 7 million bales. But the forecast for the 1949–50 crop is only about 3.33 million bales on 1.55 million acres. The greatest proportion of the raw material comes from five districts (figures in millions of bales): Mymensingh (1,138,820), Dacca (636,040), Tippera (588,455), Faridpur (558,260), and Rangpur (555,970).

The expected Indian production of 2.8 million bales (Table I) would still leave a deficit of 1.7 million bales on that country's present industrial requirement (according to a recent announcement by the Additional Secretary, Ministry of Agriculture, Government of India).

The present baling capacity in the province does not exceed 1.8 million bales annually, and the rest of the raw material is sold to the mills of West Bengal and the outside world. The world demand for raw jute comes to about 10 million bales. India bought Rs. 75 crores (about 20 million dollars) worth of jute in the 1948–49 season, which amounted to about 68 per cent of the total exports of the commodity. India has 106 jute mills out of a world total of 430. No burlap is prepared in East Bengal; all burlap making in the region is in India. The only industrial aspect of this valuable commodity in East Bengal is the existence of a number (33 in total) of *kutcha* and *pucca* baling presses. The *pucca* presses, which are undoubtedly more important, are located as follows: Narayanganj, 19; Mymensingh district, 9; Rangpur, 1; Tippera, 2; Sirajganj, 1; Chittagong, 1.

In spite of a vast world market Pakistan's position as a seller of jute is vulnerable for the following reasons: (1) The province produces inadequate baled jute and no burlap, the prices of which are high and attractive in the world market. (2) There will be a growing competition with substitutes, both natural and synthetic, though so far jute holds its own. (3) Extension of jute cultivation in India and its present relevancy to the devaluation of the

TABLE I

PRODUCTION OF RAW JUTE IN PAKISTAN AND INDIA

(Data from Jute Prices Directorate [East Bengal] Publication, 1949, pp. 17–18)

Year	*Pakistan*		*India*	
	Acreage	*Yield*	*Acreage*	*Yield*
1947–1948	2,000,000	6,800,000	651,785	1,600,000
1948–1949	1,876,565	5,479,095	765,605	2,100,000
1949–1950 (Forecast)	1,559,420	3,332,455	not available	2,800,000

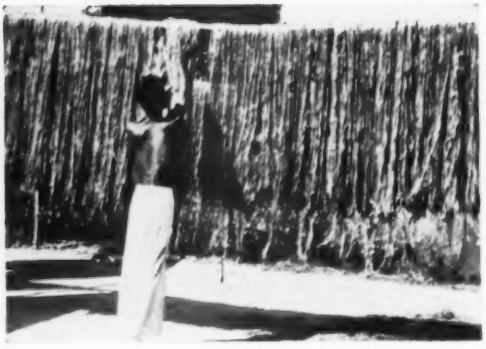

FIG. 2. Newly peeled jute fiber is being washed in semi-stagnant waters. (Photograph by Zaidis.)

FIG. 3. After washing, the fiber is left to dry in the sun. (Photograph by Zaidis.)

FIG. 4. Dried and loosely sorted the fiber is brought to the river front in Narayanganj, usually in country boats, for supply to the presses.

currency of that country has, for the moment at least, disrupted the normal trade in jute. (4) High prices during war years led to extension of jute cultivation at the expense of paddy. The present food shortage, combined with the fact that a considerable proportion of the crop could not be sold in either Indian or world markets, may well lead to a reversion to rice cultivation in some of the jute areas of East Bengal. This reversion may even have to be encouraged by some kind of legislation.

TABLE II

DESTINATION OF EXPORTS OF RAW JUTE FROM EAST BENGAL, 1948–49
(in bales of 400 pounds each)

India	4,623,000	France	153,085
U. S. A.	296,931	Argentina	88,586
United Kingdom	284,374	Italy	64,975
Belgium	237,186	U.S.S.R.	53,518
Germany	194,561	Czechoslovakia	37,510

As it is, India has been the main customer for East Bengal's raw jute; in fact India's industry leans heavily upon it. India's present jute production does not amount to more than 2 million bales.[4] But India is aiming at self-sufficiency in raw jute production and hopes to attain this self-sufficiency by 1951–52 through extending cultivation in Bihar, Orissa, West Bengal, Travancore, The United Provinces, and Assam.

The competition from substitutes (paper bags, cotton bags, etc.), though at the moment small, is likely to gather force with the maintenance of high prices. For Pakistan jute the United States of America is the major market, and yet in every month of 1949 there has been, it is reported, a lower consumption in the United States than prevailed in 1948.[5] Besides, in recent years, more particularly during the period of World War II, there have been attempts to replace jute that have usually taken four lines:[6] (1) employ-

ment of surplus materials, (2) development and extension of the cultivation of national fibres, (3) acclimatization of jute itself in other geographically favorable areas, and (4) dispensing with packing material where bulk handling would do.

Due to surplus production, especially in the United States, cotton rose as an important substitute for jute. Cotton materials are being considerably used in the United States and in Argentina for packing and sacking sugar, cotton, fertilizers, cement, etc. Similarly, the use of paper bags as a substitute for jute has increased in the United States from 201,000 tons in 1939 to 571,000 in 1947. The outside world has been attempting to grow substitute crops. For instance, Brazil has encouraged the cultivation of Guaxima, Carua, and Brazilian jute; New Zealand gave financial assistance for the growth of native flax called Phormium tenax; the Dutch began using roselle fiber bags in Java's sugar industry; and the various varieties of hemp are being utilized in countries producing those crops. Other competing crops are Fique in Colombia, sisal in East Africa, Cuban jute, and Chinese jute.

Among synthetic fibers may be mentioned German "zell" jute made from straw pulp and "Fibro," a staple rayon fiber. But all synthetic fibers so far developed have the handicap of a much higher price than jute. Urena Lobata grown in Belgian Congo provides fiber which is reported to be suitable for spinning, but its total production does not exceed 50,000 bales which fails to meet even the home requirement of Belgium. Wild Stokroo is grown in some parts of South Africa and Wild Hollyhock in Northern Transvaal. Both produce fiber, but so far their suitability in bulk packing has not been tested. Similarly, during the last year, Australia

FIG. 5. Sometimes even smaller, open boats are employed in the transport from distant godowns to the press.

FIG. 6. Even smaller bundles are carried up the gangway. Notice its temporary construction, necessitated by the shifting of the main stream of the river.

FIG. 7. Raw and uncut and ungraded jute is piled up outside the press godown under the watchful eye of the Scottish manager.

FIG. 8. From the godown the loose bale goes to the factory for cutting, hackling, and grading before the jute is pressed.

FIG. 9. This young Scottish manager is one of those experts who "tell the quality of jute by its snapping." Grading of the fiber is essential.

has been experimenting, with satisfactory results, on the growing of Sida Restusa in Queensland. Kenaf is grown in several parts of the Soviet Union. It is similar to "Hibicus Cannabinus," and in 1931 the Soviet Union started utilizing it as a substitute for jute. Besides, very recently, frost resistant varieties of jute have been developed and crops are being raised on experimental farms in Central Asia, Transcaucasia, and the Kuban Valley. Kenaf is also extensively cultivated in Manchuria. The Japanese were using it to supply about 25 per cent of Manchuria's requirement of jute. Kenaf is now also being cultivated in Cuba to meet local requirements on a small scale. Though it has its limitations, Kenaf is a potential substitute for jute.

As regards the cultivation of jute itself the efforts of India in this direction have already been mentioned. There is no doubt that given the minimum requirements of climate and soil jute can be grown in many tropical and semi-tropical countries. Other countries where some amount of success in jute cultivation has been achieved are: Nepal, Formosa, Indochina, Siam, Argentina, and Brazil. Of these countries, the best possibilities exist in Siam and Formosa, where climatic and soil conditions combine favorably with cheap labor. Fortunately for Pakistan, most of Southeast Asia is in a ferment and the establishment of stable economic conditions will take time. Finally, great jute consuming countries like the United States, Canada, and Australia are fast developing bulk handling methods by the use of mechanical grain elevators in terminal ports. This is aimed at doing away with packing materials as far as possible, and is a further challenge to jute. But so far jute has withstood this many-sided competition mainly because of its cheapness.

India-Pakistan independence and all these world developments obtaining at

present in the jute industry make it urgent that a jute milling industry be established in East Bengal. To this end the government should immediately order the necessary machinery for three mills of at least 1000 looms each. The machinery for these mills is expected to cost about 15 million dollars. Of these looms 2100 are to be employed on hessian production and 900 on sacking bags. The three mills will produce about half of Pakistan's own requirements, but after installation they will probably take at least three years to get into production. Although capital costs for these new mills will be heavy, the running costs will compare favorably with Indian mills, since the most up-to-date machinery requires only half the labor needed for the older machinery installed in Calcutta mills.

In the future, there may be developed several modern industries for which jute will be the basic raw material. Plastic treated and processed jute fibers may be utilized for making artificial leather backing for linoleum, floor covering, and roofing materials and for making artificial wool for blankets and carpets. Jute stalks by themselves or in combination with bagasse or water hyacinth fibers may lead to the manufacture of insulation and acoustic board.

If possible, some reasonable agreement should be arrived at between Pakistan and India on the maintenance of normal jute trade between the two countries. In the meantime, an urgent need is that the peasant be relieved of his surplus of the crop through a government or semiofficial purchasing agency. A Jute Board was set up by the Pakistan government in October 1949 to deal with all matters relating to jute in East Bengal. Its main activity is at present directed to the purchase, sale, storing, baling, price control, and export of raw material. Finally, in view of the aforesaid considerations, a word of caution should be sounded against an extreme "jute mindedness" in the future industrial development of East Bengal. Indeed, we should not put all our eggs in one basket! Other industries should be set up whenever and wherever possible.

COTTON TEXTILE INDUSTRY

East Bengal has at present only ten operating cotton mills. Of these, five are in Narayanganj, two each in Dacca and Kushtia, and one in Khulna. Taking the 1941 population at 41,800,000 and the per capita cloth requirements at 15 yards a year, the needs of East Bengal would be about 627 million yards or 314,000 bales per year. East Bengal mills now produce about 2500 bales per month or 30,000 bales annually, less than a tenth of the total needs. Under normal conditions, hand looms produce about 25 per cent of total needs. Thus there is still a deficit of 65 per cent. That there is ample need for expansion of the cotton textile industry needs no emphasis.

East Bengal produces only 21,000 bales of raw cotton (of 400 pounds each) per year. Production is centered mainly in the Chittagong Hill Tracts under crude methods of cultivation. The cotton commonly grown is of short staple of the variety "Comilla." But not more than 200 years ago some very fine varieties were grown on a large scale for a distance of about 40 miles along the banks of the Meghna and up to a few miles inland in Dacca district. This was also the time when some of the finest fabrics the world has ever known were produced in and around Dacca. In 1787 the exports of Dacca muslins to England amounted to 30 lacs of rupees (about 800,000 dollars). Natural conditions did not stand in the way of cotton production and its enor-

mous utilization in East Bengal, but the free importation of factory-made cottons destroyed this hand industry completely in a generation. As a result there was little left of the industry and no exports in 1817. There is no reason why a modern cotton textile industry should not be established. The home market is vast and labor and raw material facilities are locally abundant.

Another textile industry, artificial silk and rayon, should be established in East Bengal in the near future. Cellulose is the main raw material required and the cellulose bearing materials such as cotton, bamboo, wood, bagasse, and some varieties of reeds are available in considerable quantities. Since large amounts of chemicals are needed in this manufacture, the effort will have to be coordinated with the development of the chemical industry and a power project.

THE SUGAR INDUSTRY

East Bengal has only four sugar mills. Darsana (Kushtia), Gopalpur (Rajshahi), and Setabganj (Dinajpur) are of considerable size, while Shonpura (Rajshahi) is a smaller unit. Total annual production of sugar cane is small (about 9 crore maunds or 3.3 million long tons), far below the requirements of the province. The domestic consumption is roughly 1.5 million tons of sugar but only about one-tenth of it is produced in East Bengal. The chief cane producing districts are Dinajpur, Mymensingh, Dacca, and Rangpur. At present the total acreage under sugar cane in East Bengal is 224,500.

TEA AND TEA GARDENS

The production of tea is of great importance in East Bengal. It is not ordinarily realized that at the moment, due to the disruption of Indonesian production (normally 180 million pounds) East Bengal is the third largest tea producer in the world with 45 million pounds as compared with India's 560 million and Ceylon's 290 million. Pakistan has been allowed a quota of 35 million pounds of exports out of which 30 million pounds go to the United Kingdom alone for the Ministry of

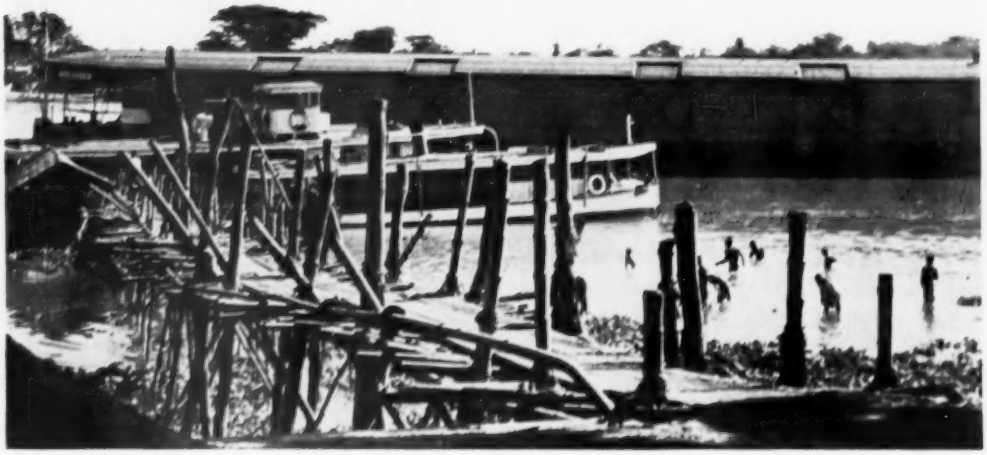

FIG. 10. After being pressed into "pucca" bales of 400 pounds each the raw material is made ready for the world market and is loaded onto these big closed barges known as "flats" and moved on to the port of Chittagong, the biggest outlet for East Pakistan.

Food. The balance goes to the United States, Canada, Europe, and the Middle East. All qualities of tea are exported except dust. Prices vary according to the grades and season of manufacture.

As a result of the Pakistan Tea Conference held in December, 1949, the target of tea production for the next five years has been put at 50 million pounds a year. It is proposed to start manufacturing one million pounds of green tea for Afghanistan and other parts of the world where green tea is popular. Improvements of existing gardens, working of those which had gone out of production, and bringing suitable extra acreage under cultivation were among the other decisions of this conference.

A few additional facts will help to round out the picture of East Bengal's tea industry. The number of tea estates of all description is recorded as 134, though many of these may have gone out of production. Several have been amalgamated with neighboring estates while many have been closed down temporarily for financial reasons. The government of Pakistan has recently appointed a special officer to make a detailed survey of the tea area so that the worn-out estates will not be licensed. Of these 100 are in South Sylhet, 10 in North Sylhet, 22 in Chittagong, and one each in Tippera and the Chittagong Hill Tracts. About 76,000 acres are under tea. No less than 150,000 workers are employed in various ways in the tea production of Sylhet district alone. The number of registered tea factories in East Bengal in 1948 was 116.

OTHER RAW MATERIALS AND INDUSTRIES

Among the useful and extensive raw materials at present not being utilized in modern industry[7] are hides and skins, and bamboos and other allied raw materials needed for the manufacture of paper. Others are tobacco with a production of about 1.5 million maunds, soft and hard timbers, bone meal, glue, guts and tallow in abundance, various oil seeds, and lac. It was only towards the middle of February, 1950, that the Development Board of the Pakistan government came to the conclusion that a paper mill capable of manufacturing 30,000 tons a year of fine and superfine qualities of paper which should satisfy the country's immediate requirements would be established near Kuptaimuk about 30 miles up the Karnafuli from Chittagong where adequate quantities of bamboo are available. It was recommended that the mill should be run by a corporation. The province produces about 1.6 million skins and 3 million hides annually. Only 15 per cent of the skins and hides is retained for consumption in East Bengal; the rest is exported to India, the United States, the United Kingdom, Czechoslovakia, and the Netherlands. Only one small modern tannery (at Narayanganj) has thus far been established, while undoubtedly about 20 such units could be suitably established. Two oil mills (Gaibandha in Rangpur and Nalchiti in Barisal), one cement factory (at Chatak in Sylhet), three tiny match-making establishments at Dacca, and a couple of small glass works at the same place complete the picture of existing industries in East Bengal.

POWER RESOURCES

The position of power production in relation to the present large scale industry in East Bengal reveals some interesting features of the limitations involved. A patent weakness is the total absence in the area of developed power based on the province's own resources. Little petroleum has been struck and coal of even fair quality is not expected to be

found in appreciable quantities. At the end of December, 1949, newspapers[8] announced that coal deposits had been discovered near Ramgarh in the Chittagong Hill Tracts, about 50 miles northeast of Chittagong, and near Madhavpur in South Sylhet, and that samples from the deposits were being tested and sketch maps of the area prepared. This obviously relates to the discovery of Tertiary coals of limited value. It is reported that Ramgarh coal contains 3 per cent sulphur and the Sylhet lignite is of poor quality.

Thus imported coal and oil continue to provide most of the thermal power. Fuels like woods, paddy husk, bagasse, and jute stalks are available in considerable quantities and their local consumption in small industries has been the custom, but they are of little significance in satisfying large scale industrial demands. Present annual requirements of fuel in East Bengal are estimated at 2 to 3 million tons of coal, 25,000 tons of fuel oil, 4 million gallons of gasoline, 350,000 gallons of aviation fuels, and 140,000 tons of kerosene. It is estimated that requirements of fuel in the next five to ten years will increase to at least three times present needs. It is believed probable that over 5 million tons of coal alone may be required.[9]

East Pakistan probably has the smallest electric power production of any province of Pakistan. Its installed capacity does not exceed 15,000 kilowatts. Only 18 towns out of 58 with populations of over 5000 are served with electricity. The present total installed capacity is about equally divided between diesel and steam plants, while roughly two-thirds of the output is generated from the former.

The demand for power has increased at an annual rate of about 15 per cent in recent years, but with the new industrial program coming into its stride this rate of increase could easily be accelerated to from 30 to 50 per cent. In fact, even a modest estimate of power required for new industries is over 60,000 kilowatts, while expansion of present industries would require an additional 30 to 40 thousand kilowatts. To meet this demand an installation of roughly 100,000 kilowatt capacity, a combination of hydroelectric and thermal power might be required.

It follows that East Bengal's industrial future depends to a large degree upon completion of the Karnafuli project. Unfortunately, whether this dam is built at the Barkhal Rapids or at the newly chosen Sublong site, it will be located in a corner of the province,

FIG. 11. Here can be seen river craft of all type from the smallest "dinghy" to steam launches and flats crowding the water front in the river port and industrial center of Narayanganj, 12 miles from Dacca, the capital of East Pakistan.

FIG. 12. A typical hill profile with tea bushes and shading trees in the chief tea producing area of South Sylhet.

FIG. 13. Young Santhali women on the early morning task of hand irrigating the tea bushes during the dry winter.

TABLE III

TOWNS IN EAST BENGAL WHERE ELECTRIC SUPPLY COMPANIES EXIST (1948 figures)

Towns	*Total units generated K.W. hours in thousands*
Barisal	436
Bhairab Bazar (at present closed)	18 (in 1946)
Chandpur	203
Comilla	431
Dacca (steam turbine)—Coal	5,821
Faridpur	288
Jessore	176
Khulna	333
Munshiganj	22
Mymensingh (steam engine)—Coal	557
Narayanganj	1,053
Pabna	422
Rajshahi	484
Rangpur	124
Sirajganj	202
Sylhet	516
Rajbari	50
Chittagong (from Pahartali Power House, steam turbine)—Coal	2,347
Total	13,465

85 miles from Chittagong, about 200 miles from Narayanganj and Dacca, and nearly 300 miles from Mymensingh. Though the power to be developed is about 40,000 kilowatts, yet the difficulty of distributing this power economically over distances in excess of 200 miles will be a limiting factor. A chain of thermal and diesel stations will have to be placed over the northern and western part of the province. The area should be divided into districts or zones, each to be served by local diesel or steam plants. Only in the eastern and southeastern part of the province does it appear that an interlinked power grid system may be developed.

PLANNING THE FUTURE

This survey of the present industrial position in East Bengal has clear implications. East Bengal has a superabundance of man power. Indeed, the pivotal fact of its economic problem is overpopulation rather than the reverse. The mineral position is fairly clear; the picture is one of paucity and limited hope in the future. The agricultural wealth is large, though there is a very numerous population pressing on it. At any rate, the province has a surplus in some agricultural and associated raw materials, such as jute, coconuts, bamboos, hides and skins, etc., and possibilities of utilization of several others. This is indicative of an agro-industrial complex in her future economic development. East Bengal's millions would provide one of the world's largest sources of labor. True, they are at the moment uninitiated in the ways of modern industry and lack efficiency and skill. But there seems no reason why two or three generations of training and organization may not make labor as skilled as in the West.

Industrialization of East Bengal is not merely a matter of expansion but also of location. The execution of both should be properly co-ordinated. Already there are signs of an initial unbalanced development. There are some urban areas like those of Dacca, Narayanganj, Chittagong, etc., in which industries seem to cluster. Yet many rural regions with rich possibilities remain remarkably backward. Therefore, to secure economic benefits on an equitable and a rational basis there should be a diversification as well as a regionalization of industrial development. Fortunately, the area is not confronted by problems of demolition and transfer and dispersal of industry. On the other hand, the task is to initiate fresh development schemes in new and suitable sites, with due regard to such relevant factors as raw material supply, source of power, availability of labor, facilities of transport, and consuming markets. Of course, the relative importance of these factors would vary in accordance with the nature of different industries and typical local or regional environmental conditions.

A plan of economic development is essential. The first requirement is a careful inventory of East Bengal's harnessable resources. Schemes of development of industry would not be rational until the possibilities are clear. It should not be overlooked that overall planning requires the cooperation of many kinds of specialists, but the proper inter-relation of minerals, climate, land use, communications, settlement, and markets, and their interpretation in terms of the complex reality is the task of the geographer.

Finally, in the execution of its industrial policy, the state's role in East Bengal should be directed along the two parallel lines of regulatory action with all possible encouragement to private capital, and nationalization of water and mineral resources and public utility concerns. Such actions should have targets in the time scale of a nationwide State Economic Plan. An immediate implementation is called for in (1) improvement of harbor, communications, and transportation facilities. As an immediate program, the development of Chittagong port is of vital importance. (2) Establishment of government trading estates. This should

FIG. 14. The typical tea factory is located in a rich green setting. This is the Dhamai tea factory one of the largest in East Pakistan.

be combined with a building and renting of factories. (3) Assistance to trading corporations and in selected cases to individual manufacturers. (4) Starting of construction work on the Karnafuli Project.

Every nation will be judged sooner or later before the tribunal of history. It will be judged in terms of its policies and actions towards its natural resources and their development for the well-being of its people. The late president Roosevelt expressed this idea well when he said, "The nation behaves well if it treats the natural resources as assets which it must turn over to the next generation increased, not impaired, in value." This is relevant to plans for the industrial development of East Pakistan.

REFERENCES CITED

1. Report of the Bengal Industrial Survey Committee, Government of West Bengal, 1948, p. 193.

2. "First Complete Jute Year," Jute Prices Directorate, East Bengal, 1949, p. 2.

3. Department of Agriculture, East Bengal, 1948–49 figures.

4. *The Statesman*, Calcutta, October 27, 1949.

5. Textile Editor in *Journal of Commerce*, New York, Aug. 31, 1949.

6. S. D. Choudhry (Economic Botanist to East Bengal Government), "Problems of Jute Substitutes," *The East Pakistan Agricultural Journal*, Vol. I, No.1 , 1949.

7. M. A. Azam (Deputy Director Industries, East Bengal Government), "The Potential Industries of East Bengal," a paper read at the First Commerce and Industries Conference, East Pakistan, Chittagong, October, 1949.

8. *The Statesman*, Calcutta, December 27, 1949.

9. S. M. Ahmed (Industrial Advisor to East Bengal Government), "Fuel and Power Resources in East Bengal and Their Development," a paper read at the First Pakistan Science Conference, Lahore, 1949.

MINERAL DEVELOPMENT IN SWAZILAND

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MINERAL discovery and exploitation have been among the major factors responsible for the economic emergence of Africa. Although the character of mining development has varied considerably from one territory to another, progress and distributional patterns have everywhere been determined by similar factors. Some of these factors are of world application, such as the distribution and relative abundance of mineral resources and their mode of occurrence. Others are comparatively unimportant in western countries with their long mineral and industrial histories, but of vital significance to Africa. Such are the influence of relief upon accessibility and upon climatic suitability of mineralized regions to European settlement, the extent of private prospecting and of official geological and mineral survey, the availability of cheap labor and of skilled technicians, distance from ports and means of communication. The remaining factors are peculiarly African, such as the existence of native lands and the complex, often unnecessarily complex, regulation of mineral ownership, prospecting, and mining. Moreover, there have been not only common factors but also common stages of development. Almost everywhere precious metals and stones were the first to be exploited, followed later by base metals, and only recently, if at all, by nonmetallic minerals. In most territories mining is still in its initial stages; only crude ore is exported, and few smelting and refining plants have so far been erected.

A territory such as Swaziland, whose mineral development and potentialities are both limited and varied, provides a concise example of African conditions. Factors and stages of development can be studied in detail. The selection of Swaziland for study is, in fact, timely. The South African Government has recently declared that Swaziland should be incorporated into the Union in order to facilitate railroad and industrial development within the territory. Yet, among the profound changes that have taken place in the territory's economy during the past decade, none has been more striking than the rapid expansion of mineral production. In the 1931 depression value of mineral output had fallen to £8,875, and the pre-war years witnessed a slow recovery to £42,164 in 1938. Ten years later production had exceeded a million pounds in value, nearly 11 times the highest figure recorded before World War II. But in 1937 Dorothy Doveton had stated: "it is difficult to forecast the future of minerals in the country, but it would appear that, unless any startling developments occur in gold, Swaziland will remain dependent upon her exports of tin."[1] Recently, tin mining has

become moribund. Although there has been a small, but by no means startling, increase in gold production, tin and gold together yielded only 3 per cent of the 1948 output. Apart from small quantities of barite, the remainder consisted entirely of asbestos. Other mineral resources are being systematically investigated by the Geological Survey Department established in 1942. Mineral production, which accounted for only one-third of the territory's exports during the thirties, now yields more than three-quarters of total exports, despite a substantially increased export of livestock products.

MINERAL REGIONS

With an area of 6704 square miles Swaziland exhibits sufficient variety and correlation of relief, geological structure, and mineral resources, for mineral regions to be clearly defined. In the west the mountainous edge of the high veld exceeds 6000 feet and averages 4500 feet above sea level. The northwestern mountains, built of Archean rocks of the Swaziland system, constitute the most highly mineralized zone of the territory. Apart from small intercalated masses of phyllite exposed by tin workings in the "older granite," which may be outliers of the main mass, the Swaziland system, represented by the Fig Tree, Moodies, and Jamestown series, is confined to a narrow strip about six miles wide along the Transvaal border. The Fig Tree series, composed of alternating shales and cherts with minor quantities of greywackes, grits, and schists, contains deposits of iron ore and manganese. It is overlain unconformably by the Moodies series consisting of quartzites phyllites, conglomerates, grits, shales, and banded ironstones. These rocks have been extensively invaded by basic intrusions of the Jamestown series, so that schists, serpentine, and various unclassified igneous rocks also occur. Chrysotile asbestos, columbium, copper, gold, lead, silver, tin, and tungsten deposits all occur within the Jamestown schists and, except for chrysotile, owe their origin to granite intrusions. In places, notably surrounding Forbes Reef, the schists form relatively flat plateaus; otherwise, the region is characterized by a succession of ridge and valley. Narrow prominent ridges, that mainly follow the strike of rocks from northeast to southwest, mark the quartzites and other hard beds; intervening valleys, frequently so deep that a height of 3000 feet may separate mountain summits from valley floors, have been eroded in the softer shales and phyllites. The resultant outcropping of beds on the valley sides has facilitated mineral exploitation, but the deeply incised streams and dense vegetation of most valley floors have hindered prospecting and made communication difficult. There are still areas that have not been studied in detail, and the mineral resources are far from being fully known. Nevertheless, mineral development has been favored, not only by the presence of considerable mineral wealth and by landforms that facilitate mining, but also by an abundance of surface water, a comparative absence of malaria, and, for reasons described later, the limited extent of native settlement. The region was, in fact, the first to be developed by Europeans.

In the southwest the Pongola system, almost certainly the equivalent of the Witwatersrand system, represents the only other area of pre-Cambrian metamorphosed sediments in Swaziland. An official survey of the mountains between Mankaiana and Hlatikulu in 1946 confirmed the view that the Lower Pongola series, consisting of quartzitic sediments with volcanic rocks and some

phyllite, is probably equivalent to the Dominion Reef series in the Klerksdorp district of the Transvaal.[2] Similarly, the Upper Pongola series, comprising quartzites, shales, and banded ironstones, and containing iron ore, gold, and kaolin, has been equated to the Hospital Hill series, the base of the Lower Witwatersrand system in the Johannesburg area. The Pongola rocks have produced a highly dissected landscape in sharp contrast to the more subdued forms of the surrounding granite. Whereas deep valleys have been eroded in the shales and phyllites, conspicuous northwest-southeast ranges, mostly approaching or exceeding 4000 feet, reveal the resistant quartzites and banded ironstones. The landforms and isolation of this region have deterred the prospector. Of the geology and mineral resources little is known. Communication, except for roads connecting the chief centers, remains restricted to rough tracks and bridle paths. Throughout most of the region malaria is prevalent in some years, but in river valleys, especially in the east, it occurs annually as a summer epidemic.

The older granite, an extensive granitic and in part gneissic complex, forms characteristically the rolling grass-covered hills of the middle veld. It also occupies portions of the high veld and bushveld, so that the formation covers nearly 60 per cent of the territory. The so-called "older granite," which includes both grey and red granites, gneisses, pegmatites, felsites, and porphyries, contributes columbium, corundum, euxenite, fluorite, monazite, talc, and tin, to the mineral resources. Development of the region, which dates from discoveries of tin in 1892, has been favored by physiographic and hydrographic factors. On the other hand, the concentration of native population in the middle veld, and the complex regulation of prospecting and mineral rights on native lands, have severely restricted the distributional pattern. Transportation has been a serious, but not insoluble, problem. In the eastern middle veld, especially in the southwestern section of the tin-bearing zone, malaria is invariably a summer epidemic.

The possibilities of mineralization in the southwest are closely associated with the relative ages of the Pongola system and the older granite. Recent work by the Swaziland Geological Survey Department indicates that granites of three different ages are present, but only one, probably the older granite, is older than the Pongola system. Of the two intrusives one is a red granite that does not contain pegmatite; the other is a grey granite that contains pegmatite and has little to distinguish it from the older granite. Identification of the granites is important because each is distinct in its mineral associations.

The rest of Swaziland, comprising the bush-covered plain of the low veld and the Lebombo range to the east, is formed by rocks of the Karroo system. The western portion of the bushveld is covered by Karroo sediments that consist of coarse grits, sandstones, shales, and coal seams. Correlation with the Karroo sediments in South Africa has not yet been definitely established, but the Ecca series in which calcite and coal deposits occur is known to be present throughout the area. Dwyka conglomerate and tillite rest unconformably on the granite floor in the south, but have not been observed in the north. Intrusions of post-Karroo dolerite have been so extensive that in some areas dikes and sills form at least 50 per cent of the rocks. The regular and gentle easterly dip of the Karroo beds has produced the slightly undulating terrain that characterizes the region north of

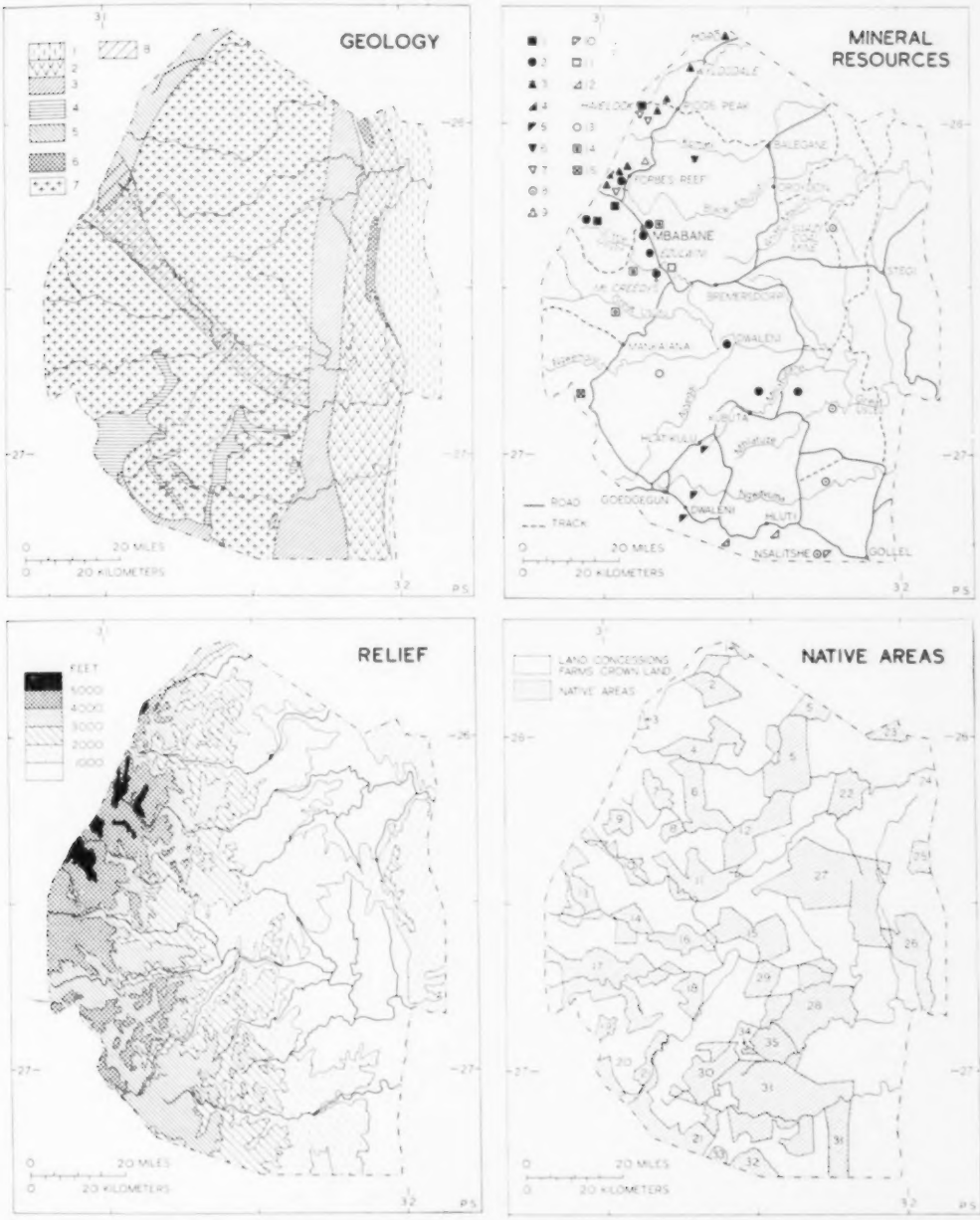

FIG. 1. The geology of Swaziland. Key: 1, Lebombo rhyolites; 2, Bushveld amygdaloid; 3, Karroo sediments; 4, Pongola systems; 5, Swaziland system; 6, porphyrites; 7, granite (mostly older); 8, tin-bearing zone. (After a provisional map by Dr. H. J. R. Way in the *Annual Report of the Government Geologist*, Swaziland, 1943.)

FIG. 2. Swaziland may be divided into four natural regions: the high veld above 4,000 feet in the west; the middle veld from 4,000 feet to approximately 1,500 feet; and the Lebombo range in the east.

FIG. 3. The mineral resources of Swaziland. Key: 1, asbestos; 2, tin; 3, gold; 4, barite; 5, corundum; 6, lead; 7, iron; 8, coal; 9, columbium; 10, calcite; 11, euxenite; 12, fluorite; 13, kaolin; 14, monazite; 15, talc.

FIG. 4. The 35 native areas in Swaziland today cover 40 per cent of the territory. In some areas, where mineral concessions are prior-dated to the land rights, mineral development by Europeans can proceed without interference by Government or Swazis; in others, where mineral rights have lapsed to the Crown or concessions are later-dated to surface ownership, prospecting is forbidden. (Compare with Figs. 6 and 7.)

the Usutu River; south of the Usutu the outcrop of the more resistant rocks, such as sandstone and dolerite, have yielded low, flat-topped hills. The region as a whole suffers from poor communications, malaria in summer, and drought in winter.

The Karroo sediments are overlain in the eastern bushveld by basic lavas that tend to be amygdaloidal. These are succeeded eastwards by a more acid series of volcanic flows ranging from porphyrites and andesites to rhyolites that together form the Lebombo monocline. They rise from the low velt by a well-defined escarpment, more pronounced in the south than in the north, to form a rugged plateau broken by three deeply-entrenched river valleys. Seawards the Lebombo range dips beneath the Cretaceous and Tertiary deposits of the coastal plain.

This region appears to lack economic mineral deposits. At Mananga Point and Stegi the Karroo shales, but not the overlying basalt, may have been receptive to mineralizers emanating from large dikes of porphyritic granophyre. If, however, the intrusive granophyre is genetically associated with the Lebombo acid volcanics, then the possibility of associated mineralization would appear to be slight. Before potential resources can be assessed, the relationship between the granophyre and the volcanics will have to be resolved.

MINERAL OWNERSHIP

A major deterrent to prospecting and mineral development has been the complicated regulation by Government of mineral rights, prospecting, and mining. Procedure necessary before prospecting varies greatly from one locality to another. During the last 60 years the position has become so confused that in some areas mineral ownership has been difficult to determine. To understand the present position a brief review of the historical background is necessary.

Gold discoveries in the high veld during the seventies, and the granting to Europeans of the first mineral concession in 1878 by Mbandeni, the Swazi king, promoted a concession-hunting boom that reached its climax between 1885 and 1889. During this period Mbandeni conceded more land than the total area of the territory and practically all the mineral rights. That he realized the significance of signing the concession documents is, of course, highly questionable. Suffice it that in 1902, when the territory came under British rule, the situation was so chaotic that a general survey of all concessions was immediately ordered. This was followed in 1904 by an examination of land titles, the cancellation of monopolies, the adjustment of disputed boundaries, and the settlement of conflicting rights.

In 1907 territorial segregation became official policy. About 38 per cent of the territory, divided into 31 separate areas, was allocated to the Swazis. A further 36 per cent was reserved for European concession-holders, and the remaining 26 per cent became Crown land. Where land had been reserved for concessionaires, the individual rights of landowners and mineral owners were defined. If the mineral rights had been conceded before the land rights, the mineral owner could, within certain limits, develop his minerals without regard to the landowner. If, however, the mineral rights were later-dated to the land rights, the mineral owner could prospect and mine only with the landowner's consent. In such cases landowners came to demand compensation for damage to arable land or pasture. Where land had been reserved for native settlement, holders of concessions prior-

FIG. 5. The original 59 mineral concessions as demarcated by the boundary commission, 1908. Since 1908, many concessions have been subdivided or have lapsed to the Crown. Today, 71 concessions can be distinguished.

dated to native areas were entitled to develop mineral resources within those areas; but holders of later-dated concessions could neither prospect nor mine without permission from the Government. Permission was seldom given. Similarly, permission to develop those portions of native areas where the mineral rights had reverted to the Crown either by deed or purchase was consistently refused. But in areas where the Crown held both the mineral and land rights, prospecting and mining under Government license was permitted after 1912.

An early period of feverish prospecting and frequently disappointing development was followed by inactivity. Few concessionaires made use of their rights. The long-term nature of the original 59 mineral concessions, most of which had been granted for 50 or 99 years with a right of renewal and some for an indefinite or unlimited period, precluded other prospectors from developing the resources. Eventually, in 1927, the Government decreed that concessionaires who were not actively engaged in developing their concessions could either pay an undeveloped-mineral tax and retain full rights, or transfer their rights to the Crown, or declare their concessions open to prospecting and mining under Government control. Owners of mineral rights in native areas naturally retained their rights. Many concessions were subsequently either transferred to the Crown or opened to prospecting. Nevertheless, the total area where prospecting is now permitted covers only one-third of the territory. Most of this area is situated in the low veld and the Lebombo range where the discovery of extensive deposits of economic minerals is highly improbable.

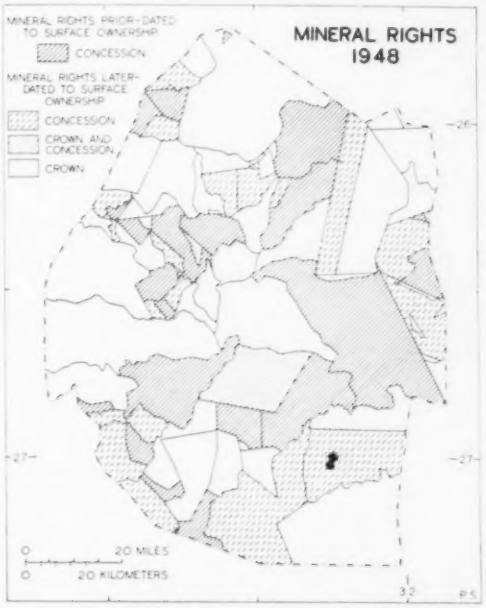

FIG. 6. Ownership of mineral rights with respect to surface ownership in Swaziland, 1948. Areas where mineral rights are *prior-dated* to surface rights may be developed without regard to landowners; they comprise 28 per cent of the territory. Areas where mineral rights are *later-dated* to surface rights may be developed only under Government license or upon payment of compensation to landowners; they cover 72 per cent of Swaziland. Licenses to develop resources in native areas are seldom granted.

None of the concessions in either the northwestern mineralized region or the tin-bearing zone has been opened to prospecting.

Since 1908 concessions have increased in number to 71, but have decreased in extent by half. For 48 per cent of the territory mineral rights are now vested in the Crown; overlapping Crown and concession rights, where base metal and precious metal ownership are separate, account for 3 per cent. Some areas may be developed only under Government license or upon compensation being paid to landowners; others may be exploited without regard to landowners, native inhabitants, or the Crown. The latter include prior-dated concessions covering the important mineralized region around Wyldsdale, Havelock, Piggs Peak, and Mbabane. Prior-dated concessions cover only 28 per cent of the territory. Crown and concession rights for the remaining 72 per cent are all later-dated. Moreover, areas open to prospecting comprise Crown areas covering 17 per cent, concessions 13 per cent, and overlapping areas 2 per cent; areas closed to prospecting consist of Crown areas covering 35 per cent, concessions 32 per cent, and overlapping areas 1 per cent. (Figs. 6 and 7. The writer wishes to thank Dr. H. J. R. Way, Chief Geologist of the Geological Survey Department in Swaziland, for kindly providing the mineral concession diagrams upon which these maps are based.) The complex position is being reviewed by Government, and presumably legislation will shortly be promulgated to regularize prospecting and mining. This should facilitate and encourage future development.

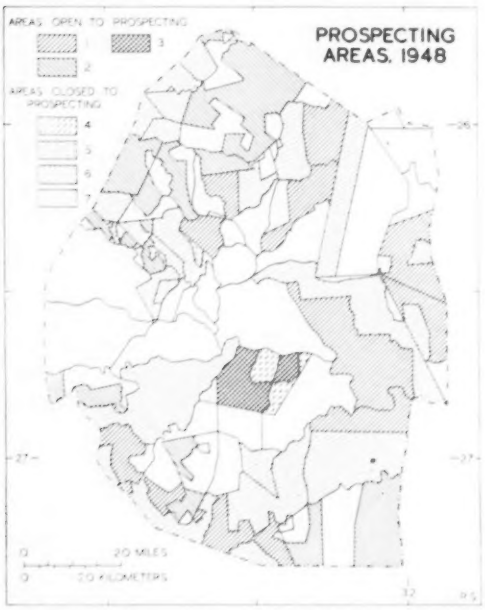

FIG. 7. Prospecting areas in Swaziland, 1948. Only 32 per cent of the territory is open to prospecting. Key: 1, concessions; 2, Crown mineral areas; 3, mixed areas (base metal rights vested in the Crown, precious metals in concessions); 4, mixed rights (division similar to 3); 5, mixed areas where mineral ownership is highly complex; 6, concessions; 7, Crown mineral areas.

FIG. 8. Although Swaziland is surrounded by rail terminals, the absence of a railroad passing through the territory has been a major handicap to mineral development. Barberton and Breyten are the most important railheads. Key: 1, railroads; 2, proposed railroad extensions that have been surveyed; 3, S.A.R. motorbus routes; 4, other roads; 5, aerial railway.

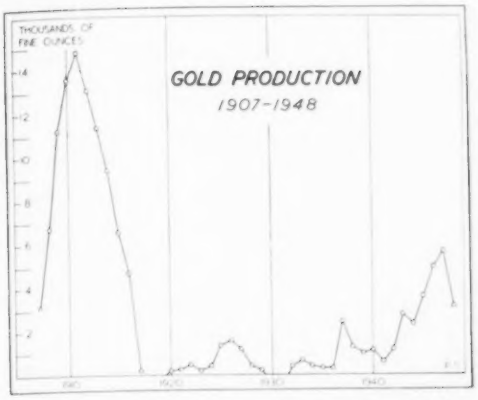

FIG. 9. Gold production in Swaziland, 1907–1948. (Data available only from 1907, and taken from Annual Colonial Reports for Swaziland 1907–1939, Annual Reports of the Government Geologist 1942–1947, and the *South African Mining and Engineering Journal*.)

THE GOLD PERIOD

Gold mining dominated mineral production in Swaziland from 1880, when the Forbes Reef mine began operations, until 1913, when tin mining assumed greater importance. During the nineties numerous gold mines, notably those at Piggs Peak and Horo, began producing. All were located along the eastern slopes of the northwestern mountains, for inaccessibility discouraged prospecting among the mountains. In 1911, the peak year in the history of gold mining in Swaziland, output reached 14,780 fine ounces. More than a dozen mines were producing. Yet, the first stage in the territory's mineral development had almost ended. By 1913 the value of tin production had surpassed that of gold, and whereas tin exports increased during World War I, gold output fell steadily. In 1918 gold mining ceased.

Subsequent production has been small. After 1920 output recovered to a small maximum of 1510 fine ounces in 1926; it was derived entirely from the Piggs Peak mine and disappeared during 1929. No production took place in the next two years. In 1937, owing to an increase in the price of gold, output reached 2410 fine ounces. Afterwards, production again declined. The recent recovery to 5637 fine ounces in 1947 may be attributed to favorable market conditions. Production comes mainly from the Piggs Peak and Wyldsdale mines.

The most important factor responsible for this erratic output has been the geological occurrence of the gold. Everywhere its occurrence consists of auriferous quartz veins intrusive at or near the contact between the older granite and the ancient metamorphosed sediments of the Swaziland system.[3] The lode deposits are dominantly replacements and fissure veins in which the gold is often associated with arsenical minerals that render treatment prohibitive under Swaziland conditions. Replacement has resulted from the occurrence of sheer zones and fissures that intersect congenial host rocks, notably crystalline schists. Sheer zones are, however, typical of all basement rocks within this region of metamorphism, traversing even the cherts and banded ironstones. Stockworks also occur in association with replacements. The fissure veins, though generally narrow, are often several hundred feet in length. Most of them are highly inclined and possess well-defined walls. Fissures and stringers are especially well developed near the contact of the schists with hard quartzites or cherts. Gold is normally irregular in distribution and for the most part visible; associated minerals, such as arsenopyrite, chalcopyrite, and galena, may occasionally be present. Everywhere, extensive faulting has hampered development.

The most important placer deposits have been those at Wyldsdale. They consist not only of terrace gravels deposited before the drainage system was rejuvenated but also of gold shed from nearby reefs. Stream gravels of

minor importance occur throughout the region.

Inaccessibility limited development. At most mines it merely retarded progress; at some it led to an early abandonment of workings. The Horo mine, situated in a densely wooded valley, had to close down through lack of transportation facilities. Wyldsdale was virtually inaccessible before the construction of a 5-mile track to the Piggs Peak road in 1946. In early days roads were not easily constructed owing to the rugged relief, the dense vegetation of the valleys, and the deeply incised streams. Bridle paths, often the only routes through the mountains, were impassable even to ox-wagons; and ox-wagons were the principal means of transportation until as late as 1930. Only the Forbes Reef and Piggs Peak mines came to be served with better roads. It is significant that Forbes Reef accounted for the largest output of any mine prior to 1912 and Piggs Peak for the largest subsequent output. The lack of railroad facilities in Swaziland has meant isolation and stunted development.

The gold reserves are unknown. The geology and mineral resources of the high veld are at present being investigated in detail by the Geological Survey Department. In the south, where ancient gold workings occur, the Upper Pongola quartzites that may be correlated with the Promise beds of the Government Reef series in the Lower Witwatersrand system have been found to contain conglomerate reefs. In the Transvaal the Promise quartzites have in places proved payable for small-scale mining, but in Swaziland preliminary sampling yielded disappointing results. Few exposures have, however, been sampled, and few of the streams draining the quartzite region have been systematically panned. Near Kubuta quartz veins have been observed in association with granitic intrusions into the Pongola rocks. Mineralization may have taken place along the contact, but the possibility of payable gold has yet to be investigated.

THE TIN PERIOD

The tin period may be regarded as extending from 1913 to 1938. Throughout this period the annual production of tin by value far exceeded the output of gold, and the aggregate production was five times more valuable. But ever since 1915, when production reached the peak figure of 618 short tons, tin mining has been declining. In 1948, despite the stimulus of high prices, output was only 23 tons. In the past, deposits at Makwanakop (due west of Mbabane), Forbes Reef, Mbabane, Ezulwini, McCreedys, Dwaleni, and north of Kubuta, have all been worked. Today, production comes mainly from Mbabane and McCreedys.

Most of the known alluvial and eluvial deposits, from which cassiterite has been extracted, are now almost exhausted. The deposits originated from the weathering and erosion of tin-bearing pegmatites occurring at or near the contact of the older granite with the ancient rocks of the Swaziland system.[4] The cassiterite-bearing zone, some 10 miles wide at Oshoek on the Transvaal border, extends southeastwards to the Mhlatuzane River where, some 2 miles in width, it disappears beneath the Karroo sediments (Figs. 1 and 3). The occurrence would thus appear to be remote from the contact, but investigations in this zone have revealed the older rocks as tongues of fine-grained schist or phyllite interbanded with gneiss. At Forbes Reef cassiterite occurs as veinlets in or near the walls of an aplite vein intrusive in a coarse schist.[5] Elsewhere, the only

source lodes that have been proved sufficiently productive to warrant mining occur at Mbabane and McCreedys.

The heavy rainfall, marked relief, and abundance of surface drainage, have concentrated alluvial deposits along the river valleys and facilitated the methods of working. In the east water resources are limited, so that only small-scale workings have been possible north of Kubuta. But the mountains around and to the south of Mbabane exhibit an intricate network of furrows, some of them 15 miles or more in length, that have been constructed to tap the headstreams of the drainage system. The utilization of all available water as a source of power for breaking ground as well as for sluicing has permitted the working of low-grade deposits. The overburden normally varies from 10 to 15 feet, but at McCreedys as much as 60 feet had to be removed. The marked relief has contributed by producing working heads of pressure. In many places, however, the presence of boulders has hindered operations. Unfortunately, most of the richer and more easily workable deposits, especially those served by water furrows, have been worked out. A few patches containing six pounds or more per cubic yard may still be found, but deposits now being exploited contain only about eight ounces per cubic yard.

Tin mining has recently been discouraged by the Government's attitude toward river pollution. Mining by monitor, but not sluicing, has had to be discontinued. Legislation fixing the maximum quantity of silt in tailings that may be discharged into a stream will probably be promulgated shortly.

Poor communications continued to handicap development throughout the tin period. Although in 1928 the South African Railways instituted a bus freight service which links the tin-mining region

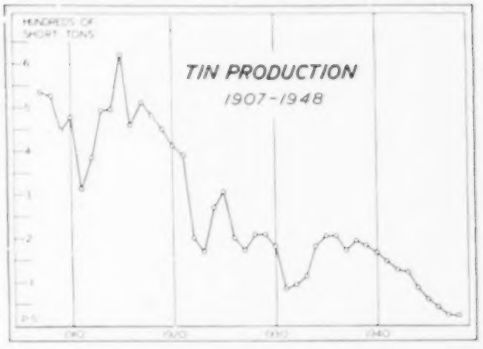

FIG. 10. Tin production in Swaziland, 1907–1948. (For sources of data see Fig. 9.)

with the Breyten rail terminal, areas away from main roads remained difficult to reach. Dwaleni, for example, is connected to the Mankaiana road by an almost impassable track, 15 miles long, that necessitates fording the Ngwempisi River and numerous smaller streams. Even Makwanakop remained extremely difficult to reach until a three-mile track was constructed to the Mbabane-Oshoek road in 1946.

Other factors have contributed to the decline in tin mining. The placer miner has almost always been refused permission to develop resources in native areas because of his utilization of water supplies, destruction of fertile soils, and undesired tailings disposal. Thus the tin-bearing gravels along the Mhlatuzane River in Native Area 28 have not been worked because the mineral rights are later-dated to surface rights. Moreover, important mining houses holding extensive concessions in Swaziland are not interested in operations that yield small profits. Prior to 1944 the returns from tin mining were particularly small: the price of tin in South Africa was controlled at a low figure; deposits were mostly low grade; and the costs of labor, of equipment, and of transportation, were high.

The small scale on which operations have been conducted and the fluctua-

tions in output have been responsible for a varying demand for labor, a highly unstable labor supply, and to some extent for the conditions prevailing in native compounds attached to the mines. Before World War II some 50 Europeans and nearly 800 Swazis were engaged in tin mining.[6] Most of the natives lived in temporary huts that lacked proper sanitary arrangements, were frequently overcrowded, and had become notorious for drunkenness and immorality.[7] Owing to the mines being located either near or within native areas, some of the workers were able to avoid the compounds and live at home. Today the scale of operations demands, perhaps fortunately, only a small labor force. Wages have risen but living conditions have shown little improvement.

THE ASBESTOS PERIOD

Since 1938 asbestos production has completely overshadowed all other mining activity. Output has risen from 4591 short tons in 1939 to a maximum of 32,660 short tons in 1944. This level was maintained for 1946 and 1948 (32,138 and 32,431 short tons respectively), but intervening years recorded a decrease in output. The promising recovery of gold production during this period and the development of corundum and barite deposits has been insufficient to compensate for the collapse of tin mining. Consequently asbestos has been steadily increasing in relative importance, contributing 69 per cent by value to mineral production in 1939 compared with 96 per cent in 1948.

Chrysotile, a fibrous variety of serpentine and the most valuable type of asbestos owing to its spinnability and resistance to heat, has been located in many areas of northwestern Swaziland. It occurs as narrow veins and stringers

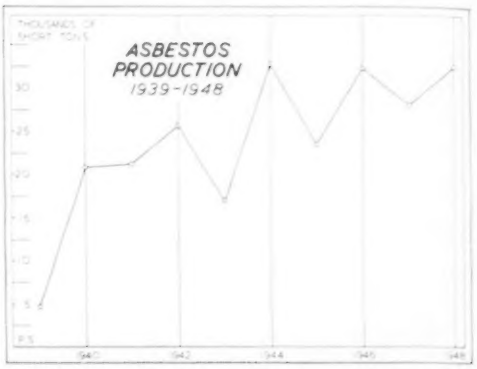

FIG. 11. Asbestos production in Swaziland, 1939–1948. (Data from Annual Reports of the Government Geologist 1945–1947 and the *South African Mining and Engineering Journal*.)

in bodies of serpentine forming a distinct horizon in the Jamestown schists. Most of the veins are not continuous over any distance and payable bodies are limited in extent. But at Havelock a large body is being worked by the New Amianthus Company. Here the occurrence consists of pale green serpentine carrying a stockwork of chrysotile veins about three-quarters of an inch wide. The deposit strikes approximately east-west and dips 50° to the south.[8] Situated on the southeastern slopes of Emlembe Mountain it can be worked both by open-cut methods and by adits driven into the slope to tap the deposits at depth. The veins are nowhere sharply defined, but grade into serpentine containing an uneconomic quantity of chrysotile. The limit of payable ore is reached when fiber recovery falls to 4 per cent of the rock mined. As yet neither the genesis nor geology of this deposit, which reveals some remarkable geological features, has been studied in detail. Other payable but smaller deposits probably occur in the Swaziland system, especially south of the Komati River.

The Havelock asbestos deposit was discovered in 1928, but lack of transportation facilities held up production for nearly ten years. Motor transport

was unable to reach the site until 1932 when a track was built connecting the mine with Piggs Peak. In that year operations began on a small scale, but were soon abandoned. Large-scale development awaited the completion of an aerial railway constructed to transport the asbestos 16 miles over rugged, mountainous country to Barberton, the nearest railhead in the Union. Mining started again in 1937. Exports date from 1939.

The Havelock mine employs over 80 per cent of the 150 Europeans and 3000 Swazis engaged in mining in the territory.[9] The company's policy has been to stabilize the native labor supply by providing good accommodation, modern sanitation facilities, adequate feeding arrangements, and married quarters. This presents a marked improvement upon conditions at tin mines where native workers are regarded as temporary. Probably the Havelock conditions reflect not only a more enlightened policy, but also the shortage of local labor in the high veld resulting from the sparse distribution of native population, the larger scale of operations, and their greater stability.

Corundum

During 1942 and 1943 a total of 172 short tons of corundum, valued at £1643, were produced. Since corundum was regarded as a strategic mineral during the war years, legislation was promulgated to facilitate the working of deposits in areas where the position regarding mineral rights had become so complex and obscure that development would otherwise have been impossible. Although corundum has been found in uneconomic quantities in alluvial tin-

FIG. 12. The Havelock asbestos mine. (Courtesy of South African Railways.)

stone deposits in central Swaziland, it occurs in payable quantities only in the south near Hlatikulu and Goedgegun where workable cassiterite is unknown. Corundum occurs in the border zone between extensive intrusions of pegmatite dikes and remnants of basic igneous rocks. The corundum-bearing rock, called plumasite, consists of porphyritic corundum crystals up to 12 inches long in a matrix of fine-grained felspar and biotite with some corundum.[10] Production has been derived from eluvial deposits and semi-decomposed rock in situ. Both the pegmatite and plumasite are so friable that blasting is unnecessary. The corundum individuals have been weakened by decomposition along cleavage planes and break up on extraction or during excavation to form hexagonal-shaped crystals rarely more than six inches long. Owing to the sporadic occurrence of corundum, its low grade, its low price on South African markets, and the high costs of transportation to the Union, large-scale development is improbable. During 1942–43 workings alongside the Hlatikulu-Goedgegun road reached a depth of 50 feet. Costs of deeper mining and of extraction from plumasite are prohibitive. Other deposits may, however, be discovered and developed as the territory becomes more intensively surveyed.

Barite

Barite occurs in the quartzites and cherts of the Moodies series. In 1943 a workable deposit was discovered at Londosi to the west of Forbes Reef. The veins which comprise an admixture of barite and quartz are fine-grained and pure white. Of the three barite-bearing zones that can be distinguished, only the lowest is of economic importance. This zone, which varies from seven to over 12 feet in width, contains at least seven lenses of barite from half an inch to over five feet in thickness. It has been traced along the strike from north to south for at least 1410 yards; it dips about 25° eastwards. The barium sulphate content of the veins averages about 85 per cent.[11] The deposit is situated on European land where Crown mineral rights are later-dated to surface rights.

Production began in 1945. Output for the first four years amounted to 632 tons valued at £3,968. This was derived entirely from surface workings, but inclined shafts have been sunk along the dip as a preliminary to underground mining. The construction of a track has enabled barite to be transported by motor truck to the Mbabane-Breyten motorbus route. Since bus freight rates are high, the additional costs of transportation by truck are probably too heavy to permit large-scale development of such a low-priced commodity. To reduce export costs an aerial railway is being built from Londosi to the bus route, and crushing machinery and an air separator unit have been installed at the mine. These improvements in processing and transportation should permit a greatly increased annual production. Ore reserves have been estimated at one million short tons with the possibility of an additional million tons.[12] The remarkable strike length of the main barite zone, the high barium sulphate content, the extensive reserves, the availability of water supplies, the relative ease of access—these are the chief factors favoring large-scale mining in the near future.

COAL AND IRON

Coal

In the low veld the lack of railroads, the presence of malaria in summer, and the absence of surface water supplies over extensive areas in winter, have

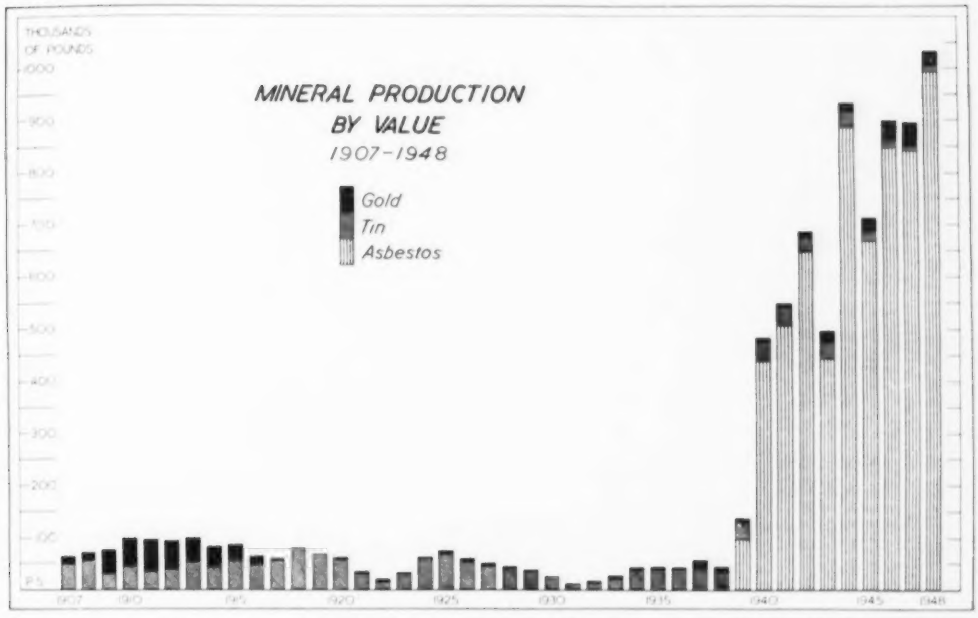

FIG. 13. Swaziland mineral production by value, 1907–1948. Comparison with Fig. 11 shows that the quantity of asbestos produced in 1948 did not exceed the 1944 output, despite 1948 being the first year in which mineral production exceeded one million pounds in value. Production of corundum and barite have been too small to be indicated. (For sources of data see Fig. 9.)

been the major obstacles to prospecting. During the seventies coal was discovered near the confluence of the Black and White Mbuluzi Rivers. Later, a shaft was sunk at the Swazi coal mine near the White Mbuluzi River and an adit driven into Nsalitshe Hill in the south; although some mining took place, neither systematic exploitation nor detailed assessment of resources has yet been attempted. Analyses of coal taken from deposits formerly worked indicate that the seams include semi-bituminous, semi-anthracitic, and anthracitic coals with about 9 per cent ash content at the Swazi coal mine[13] and 12 per cent at Nsalitshe.[14] The seams have limited value owing to their marked discontinuity, their variable thickness, and local metamorphism resulting from dolerite intrusions. Both deposits are situated on European farms with the mineral rights later-dated to surface ownership; the Swazi coal mine is held by concession and prospecting is not allowed; at Nsalitshe the mineral rights are vested in the Crown and prospecting is permitted.

Iron

Old Bantu iron pits occur in ferruginous Pongola shales near Kubuta.[15] Although iron ore is known to occur in several southern localities, no prospecting has been undertaken. Recently, however, payable ores have been discovered in the Swaziland system. A few deposits, notably at Iron Hill southwest of Havelock, at Nottingham Hill southeast of Havelock, and at Darkton southwest of Forbes Reef, have been surveyed. According to official estimates they contain 215 million short tons of hematite of the Lake Superior type, but larger reserves undoubtedly exist in the region. The deposits consist of secondarily enriched sedimentary ores in the shales and cherts of the Fig Tree series. The Darkton deposit, which in 1947 was provisionally esti-

mated to contain 160 million short tons of hematite averaging 45 per cent iron, is still being examined. At Nottingham Hill the reserves were provisionally estimated in 1946 to be 30 million tons carrying 50 per cent iron. At Iron Hill, the only deposit examined in detail to date, there are 15 million short tons of 45–62 per cent iron ore, low in phosphorus and sulphur but high in silica.[16] The high silica content may present a major problem in its utilization, but the silica is so friable that the problem might be solved by beneficiation processes. The ore body, intruded by several decomposed porphyritic dikes, is 900 yards long with a maximum width of 180 yards. Outcrops on the mountain slope indicate a minimum depth of 125 feet, but much greater depth is probable. The deposit is situated in Native Area 3, but mineral rights are held by private concession prior-dated to surface ownership. The area is remote, but not inaccessible. Nevertheless, neither the Iron Hill deposit, nor the Swazi coalfield 50 miles to the east, nor the Nsalitshe limestone occurrence 90 miles to the southeast, which together provide the basis for a potential iron and steel industry, can be developed without railroad connections to existing railheads.

OTHER MINERAL RESOURCES

Deposits of vermiculite and of copper, mercury, manganese, and tungsten ores have been reported from various localities, but upon detailed investigation none has been found to be of economic significance. Other mineral resources are being surveyed by the geological department, but most of them are low-priced commodities requiring railroad facilities for profitable exploitation. The complex ownership of mineral and surface rights has again been a factor hampering development.

Calcite

At Nsalitshe Hill calcite veins, formed probably by the leaching of post-Karroo dolerite, occupy fissures at or near the contact of Karroo sandstones with an overlying dolerite sill. The veins outcrop on the northern slopes, and contain coarsely-crystalline calcite with a calcium carbonate content exceeding 97 per cent.[17] Such high-grade lime would be excellent for agricultural, if not for industrial, purposes. In the middle veld the acid soils of the mixed farming areas are in urgent need of lime application. It is probable that crushed calcite could be marketed in Mbabane at a lower price than that ruling at present. But a limited demand and the high freight rates charged by S.A.R. buses are the major obstacles to development.

Columbium

In 1944 columbite, which yields the rare metals columbium and tantalum, was found to occur in pegmatite dikes in the older granite northeast of Forbes Reef.[18] The occurrence is situated on a European farm where mineral rights are later-dated to surface ownership and have lapsed to the Crown. Prospecting is permitted. The dikes are, however, too small, and alluvial deposits too erratic in distribution, to justify extraction. Moreover, the columbite contains only 20 per cent tantalum, a far more valuable metal than columbium. Associated with columbite in alluvial deposits are magnetite, cassiterite, and monazite. It is not improbable that workable eluvial or pegmatite deposits may be found in the future.

Euxenite

Euxenite consists of mixed columbates and titanates of yttrium, cerium, uranium, iron, and calcium.[19] Ever since 1898 rounded grains of this complex mineral have been found in alluvial tin

concentrates, but never in sufficient quantity to be payable.[20] In 1913 a kaolinized pegmatite containing euxenite, beryl, and muscovite, was located at McCreedys. Despite recent interest in the occurrence, its extent and workability have not been assessed.

Fluorite

Although two separate occurrences of high-grade fluorite have recently been found in southern Swaziland, they appear to form part of an extensive region of fluorite mineralization.[21] The mineral occurs in the older granite as veins, lenses, and single crystals, in silicified zones. Deposits near Hluti, situated on Native Area 31 where mineral rights are held by the Crown, are by no means so large as those further to the west, where mineral rights are held by private concession and prospecting is permitted.

Kaolin

In 1946 extensive bodies of high-quality kaolin, presumably derived from the decomposition of felspar, were located in the Upper Pongola sediments between the Ngwempisi and Assegai Rivers. An adequate water supply for processing the china clay is insured by the presence nearby of perennial streams. The kaolin occurs on European land where the mineral concession is prior-dated to surface ownership. Prospecting is not allowed. A rough track 12 miles long connects the area with the main Piet Retief–Mankaiana road.

Lead

Galena is known to occur in Native Area 6, but the occurrence has not been investigated. The original mineral concession has lapsed to the Crown and the area is closed to prospecting. Near Darkton crocoite (lead chromate) occurs as small, well-developed crystals in vugs in quartz stringers concentrated at the contact between the Jamestown schists and the quartzites of the Moodies series.[22] Since crocoite is a mineral of secondary origin resulting from the reaction of chromic acid solutions on lead sulphide ores, the crocoite probably passes into economic deposits of galena at depth. Mineral rights are, however, held by private concession later-dated to European land rights, and the area is not open to prospecting. Crocoite also occurs in gold mines near Forbes Reef.

Monazite

Monazite is sparsely distributed throughout the granite, gneiss, and pegmatite, of the tin-bearing zone. Small, worn crystals are found in alluvial tin deposits, but workable quantities probably exist only at Ezulwini and Mbabane.

Talc

Veins of fine-grained talc admixed with dolomite occur in serpentine at the Havelock mine. Other deposits have been located in basic schists within the older granite, notably northeast of Kubuta and in southwestern Swaziland. The latter occurrence promises to be the only one of potential value. The deposit is situated on European land where the mineral rights are held by private concession later-dated to surface ownership. Prospecting is not permitted.

TRANSPORTATION

Because the mineral resources mainly comprise low-priced commodities of which the entire production is exported, the lack of railroad facilities, the high freight rates charged by the S.A.R. motorbuses, and the extensive areas without means of communication, have been major handicaps to development. In 1902 the South African Government

in agreement with the Portuguese Government undertook to construct a railroad through Swaziland to Lourenço Marques; the Portuguese built a line to Goba, but the Union failed to fulfill its obligation. In 1911 South African policy was defined in the Mozambique Convention: "if and when Swaziland becomes a portion of the Union, the construction of a railway will be considered." Later, the proposed construction of privately-owned railroads was strongly opposed by the Union Government. Transportation difficulties were to some extent relieved by the introduction of motorbus services in 1928, but they favored agricultural rather than mineral exports. Only the southern fringe of the northwestern mineralized region has been served by buses. Freight charges for combined road and rail transportation are in any case higher than those for rail transportation alone, although bus freight rates appear to be lower than the corresponding cost of private truck transportation.

Swaziland is served by six railheads situated within 50 miles of her borders. As far as the northwestern region is concerned, Barberton and Komatipoort provide outlets to Lourenço Marques, while Barberton and Breyten serve the Johannesburg market. Lothair, though nearer Swaziland than Breyten, lacks road connections with the territory. Piet Retief and Gollel provide outlets to Durban, but are remote from mining activity. Goba provides a potential outlet for the northern bushveld.

Proposals for rail connections or extensions have envisaged agricultural rather than mineral development. Among the suggested routes those from Lothair to Island Drift and from Piet Retief to Gollel have recently been surveyed by the Union Railway Administration.[23] Although neither was selected primarily to facilitate mineral exports, any extension from Lothair to the border could have a branch line to tap the northwestern region. Nevertheless, there seems little likelihood of railroad construction taking place in the near future, and much of the territory's mineral wealth must perforce remain unexploited.

CONCLUSIONS AND FUTURE

In Swaziland the complex ownership and regulation of mineral rights, which are divorced from surface rights and complicated by the existence of native areas, have had a profound influence on prospecting and mining. Development before 1939 was carried out entirely by individual prospectors and small enterprise. Activity was limited not only because known mineral resources consisted mainly of scattered, low-grade deposits of gold and tin, but also because the mineral rights for much of the territory were held by concessionaires who neither developed their property nor permitted prospecting. Such concession-holders were mainly large mining houses discouraged by the limited potentiality and lack of transportation facilities. Legislation promulgated by the Government to facilitate prospecting on undeveloped concessions served to increase the complexity of prospecting regulations and deterred the independent prospector.

Development since 1939 has been concerned largely with asbestos mining. Although reserves have been sufficient to warrant the construction of an aerial railway from Havelock to Barberton, distance from market has necessitated the export of only best-grade fiber. Apart from asbestos, development has remained in the hands of individual prospectors and small enterprise. But only one-third of the territory is open

to prospecting. Of the known mineral resources awaiting development, only limited deposits of calcite, coal, columbium, and fluorite occur in areas where prospecting is permitted. Other coal and fluorite deposits, together with euxenite, iron, kaolin, lead, monazite, and talc, all occur in areas closed to the prospector.

The Geological Survey Department, instituted as late as 1942, is making a significant contribution to future development. It has already undertaken a provisional survey of the geology of Swaziland, investigated in detail most of the known resources, and made important discoveries. That the complex regulations regarding prospecting and mineral rights will shortly be simplified is almost certain. This should encourage development by individual prospectors. At present transportation costs render the exploitation of such low-priced deposits as coal unremunerative. But the coal deposits in the low veld, together with the water resources of the Komati, Mbuluzi, and Usutu Rivers, provide potential raw materials for the production of oil from coal—an industry that is likely to become important in South Africa in the near future. Meanwhile, the large mining houses will probably continue to be disinterested in mining activity in Swaziland until such time as railroad facilities become available.

REFERENCES CITED

1. D. M. Doveton, "The Human Geography of Swaziland," *Inst. of Brit. Geographers, Pub. No. 8*, London, 1937, p. 76.

2. A. T. M. Mehliss, "The Geology of the Country between Mankaiana and Hlatikulu, Central District, Swaziland," 1946 (unpublished).

3. A. L. Hall, "Geology of the Barberton Gold Mining District," *Union of South Africa Geol. Surv. Memoir No. 9*, Pretoria, 1918.

4. *Idem.*, "Notes on the Tin Deposits of Embabaan and Forbes Reef in Swaziland," *Trans. Geol. Soc. S. Africa*, Vol. 16, 1913, pp. 142–146.

5. G. W. Bond, "Notes on the Mineralized Belt of the Jamestown Series, Forbes Reef, Northern Swaziland," *Trans. Geol. Soc. S. Africa*, Vol. 32, 1929, pp. 177–186.

6. *Colonial Annual Report No. 1921*, Swaziland, 1938, London, 1939, p. 13.

7. H. Kuper, "The Uniform of Colour: A Study of White-Black Relationships in Swaziland," Johannesburg, 1947, pp. 12–13.

8. H. J. R. Way, *Annual Report of the Government Geologist*, Swaziland, 1942, Mbabane, 1943, pp. 9–10.

9. Commonwealth Relations Office, *Annual Report on Swaziland*, 1946, London, 1948, p. 20.

10. H. J. R. Way, *Annual Report of the Government Geologist, Swaziland*, 1943, Mbabane, 1944, pp. 12–13.

11. A. T. M. Mehliss, "Report on the Barytes Deposits on Crown Mineral Area No. 7," 1946 (unpublished).

12. Minutes of the Twelfth Session of the Seventh Advisory Council of the Swaziland Territory, 1948 (mimeographed), p. 31.

13. J. J. Garrard, "The Geology of the Swaziland Coalfield," *Trans. Geol. Soc. S. Africa*, Vol. 17, 1914, pp. 75–84.

14. H. J. R. Way, *Annual Report of the Government Geologist*, Swaziland, 1942, Mbabane, 1943, p. 15.

15. G. N. G. Hamilton, "The Geology of the Country around Kubuta, Southern Swaziland," *Trans. Geol. Soc. S. Africa*, Vol. 41, 1938, pp. 41–81.

16. A. T. M. Mehliss, "The Hematite Deposits Mineral Concession No. 41, Northwestern Swaziland," *Swaziland Geol. Surv. Special Rept. No. 1*, Mbabane, 1946.

17. H. J. R. Way, *Annual Report of the Government Geologist, Swaziland*, 1943, Mbabane, 1944, p. 19.

18. *Idem, Annual Report of the Geological Survey Department, Swaziland*, 1944, Mbabane, 1945, p. 16.

19. G. T. Prior, "Minerals in Swaziland: Niobates and Titanates of the Rare Earths, chemically allied to Euxenite and Fergusonite," *Min. Mag.*, Vol. 12, 1898, pp. 96–101.

20. A. W. Rogers, "Notes on the Occurrence of Radioactive Minerals in South Africa," *Trans. Geol. Soc. S. Africa*, Vol. 18, 1915, p. 5.

21. H. J. R. Way, *Progress Report of the Geological Survey Department, Swaziland*, 1945–1946, Mbabane, 1948, p. 32.

22. *Idem, Annual Report of the Geological Survey Department, Swaziland*, 1947, Mbabane, 1949, p. 20.

23. V. Liversage, "Swaziland Development," Mbabane, 1947 (mimeographed), p. 8.

INDUSTRIAL DEVELOPMENT IN FORMOSA*

Eugenia Gage

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THE industrial rise of Formosa (also known as Taiwan) is a late event in the island's history. In the early decades of this century its economy was almost entirely agricultural. Rice, sugar, tea, and fruits were sent to Japan, the governing nation, in exchange for fertilizer, textiles, and other manufactured products; and the island had developed related industries such as the production of crude sugar and canning and processing. Then, in 1932, the Japanese began more intensive development of the island. Schools were established, railroads and highways were built, harbors were improved, hydroelectric power was developed, and heavy industries were launched. By 1937 exports and imports were double the 1933 figures and per capita foreign trade was close to the highest in the Far East. The ports of Keelung in the north and Kaohsiung in the south and their surrounding areas had become highly industrialized.

Except for the fact that Formosa's economy was tied to Japan's with respect to the final fabrication of certain metal products and that the island was dependent on Japan for fertilizer, it had become a well integrated and largely self-contained region. This rapid development was primarily due to one outstanding factor: Formosa's potentialities for low-cost power. By reason of this cheap power, along with other resources, Formosa is a conspicuous example of economic development conditioned and favored by geography.

Japanese rule of Formosa was terminated by World War II. The Cairo Conference in 1943 assured the return of the island to China. Accordingly, at the conclusion of hostilities in 1945, after 50 years of Japanese occupation, Formosa was taken over by the Chinese Government. A new phase in the industrial story had been initiated.

Physical Background for Industry

Location is a primary factor in the geography of any area, and in this respect Formosa is uniquely favored. It is located in the subtropics; in fact the Tropic of Cancer crosses the island a little south of the middle. Furthermore, Formosa derives considerable importance by virtue of its position with respect to its neighbors. It lies 200 miles from northern Luzon and 641 miles from the southernmost tip of Japan. Still more important is nearness

*Miss Gage's paper was received in July, 1948, and is of interest in stating the situation as it then appeared. Naturally, the article takes no account of political and economic changes in Formosa since that date.

to China. Formosa is separated from Fukien Province of China by the Strait of Formosa, less than 100 miles across. It is half way between Shanghai and Hong Kong. From its southern port of Kaohsiung the distance to Manila is 550 miles, to Saigon 1200 miles, and to Singapore 1850 miles. From its northern port, Keelung, it is less than 1000 miles to central Japan.

Formosa is a moderately large island, with an area of about 14,000 square miles, a little less than one-third the size of Cuba. Elliptical in shape, the island extends approximately 250 miles from north to south and is about 80 miles from east to west at its widest point.

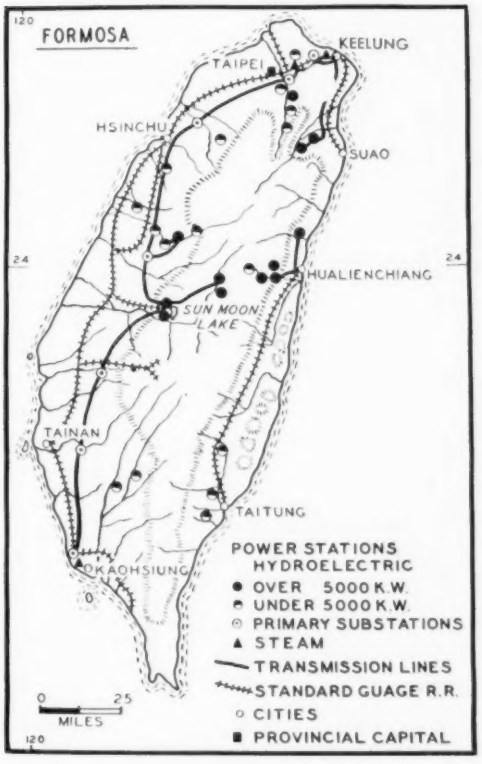

FIG. 1. Map of Formosa showing general landform features—the mountainous area comprising the central and eastern portions of the island, the numerous short rivers—and the consequent disposition of hydroelectric power stations and auxiliaries. The principal population centers situated on the western coastal plain and the main railroad lines connecting them also are indicated. Taipei, the capital and largest city, has a population of 340,000; Tainan, the second largest city, 131,000; the two ports and chief industrial cities, Keelung and Kaohsiung, over 100,000 each.

The general configuration of Formosa is that of a fault block tilted westward. This is reflected in a longitudinal mountain mass, its crest lying nearer the east coast than the west. The fairly recent origin of these mountains explains the frequent earthquakes in Formosa which have required special provisions in the design of buildings. The highest elevation in the mountain mass is close to 14,000 feet but some 60 peaks exceed 9000 feet in elevation. In fact two-thirds of Formosa may be classed as mountainous. The eastern edge of the main mountain mass forms one side of a narrow, boxed-in valley which is very difficult of access from other parts of the island and is separated from the Pacific Ocean by a secondary, lower mountain range. From the divide formed by the major mountain mass the surface of the island slopes westward to a wide plain along the west coast.

From the standpoint of intensive use the western plains are by far the most important part. This alluvial belt running the length of Formosa makes up somewhat less than one-third of the island's area but is the real living space. Particularly important is the southern two-thirds of the western plains belt to which plantation agriculture is largely limited.

In Formosa's climate several influences are notable. Subtropical location, the presence of a great mountain mass, a warm ocean current off shore, the island's nearness to the continent—all have their effects. Although the higher peaks are snow-capped at least part of the year, the lowlands, by virtue of the warm Kuroshio ocean current, do not reach as low temperatures as does the mainland in the same latitude. There is no

frost in the lowlands, but on the other hand the temperature seldom reaches 100° F.

Rainfall shows wider variations than temperature. In general, stations in the mountains of Formosa and stations backed by high mountains have much greater than average rainfall totals. Thus Keelung in the extreme northeast has an average of 289 inches per year with 215 rainy days, whereas parts of the western plain have averages as low as 40 inches with many more hours of sunshine. During the winter months (October to March) northeast monsoons reinforce the trade winds. The result is copious precipitation, especially in the north where the orographic influence is notable. During the summer months the weaker southwest monsoons prevail. They bring the west coast its heaviest rainfall. Coincidental with the southwest monsoon is a typhoon season, during which three or four serious storms may be expected. These storms bring very heavy rain to the steep eastern slopes of the island. Though typhoons are most serious in the eastern and southern parts of Formosa they do considerable damage in other sections as well. For example, possible wind damage is a factor to be considered in selecting sugar cane varieties.

The considerable rainfall of much of Formosa is reflected in numerous short rivers. They tumble to the coast from the mountainous interior, giving the island its large resource of hydro-electric power. The westward-flowing streams are valuable, too, as a source of irrigation water for use on the western plain.

Nearly three-fourths of Formosa is in forest. Most of this wooded land consists of a cover of camphor, cypress, and other species typical of southeastern Asia. In the higher mountain ranges are large tracts of pine, of a variety suitable for pulp manufacture. Formosa's timber resources are in fact valuable, and are a potentially important export. About one-third of the total island area is classed as arable land, but as a result of the broken topography of the island soils vary widely in character and fertility. There are, for example, areas of relatively heavy clay soils, difficult to cultivate except with heavy equipment. This is particularly true of the north. The alluvial soils of the southwest are considered the best for plantation use, but relief even in this section is great enough to require terracing, which makes the use of mechanized equipment difficult. Moreover, like so many tropical soils, those of Formosa are largely lateritic in character and require heavy fertilization. Fertilizer plants making calcium cyanamide and superphosphate were established in Formosa just prior to World War II, but the combined output of the new plants supplied only about one-fifth of the quantity of fertilizer consumed annually. Though these plants are now operating at better than pre-war capacity, Formosa is still dependent on imports for nitrogen fertilizer.

Not notably rich in minerals Formosa is probably better favored than Japan in this respect. Coal, some of it of fair quality, is the most important mineral resource, but petroleum and natural gas, salt, limestone, pyrite, and copper are present in sufficient quantities to have been mined in pre-war years, and gold deposits, too, are reported to occur.

TABLE I

MAXIMUM MINERAL TONNAGES BEFORE WORLD WAR II

In metric tons per year

Coal	2,500,000
Salt	380,000
Limestone	370,000
Iron pyrite	30,000
Copper	5,000

From an industrial standpoint it is significant that there is enough coal for industrial plants and some for export. The pyrite is considered sufficient for sulphuric acid production for the fertilizer plants. The limestone production is adequate for the cement industry and for the needs of the pulp and paper industry. Although sulphur is not shown in Table I a sulphur mine was formerly operated to furnish raw material for the pulp and paper industry. Thus all pulping chemicals can be obtained on the island.

THE PEOPLE OF FORMOSA

In 1944 Formosa's population numbered 6,700,000. The 450,000 of this number who were Japanese have now been repatriated except for some 2000 who were allowed to remain as technicians, factory supervisors, etc., until replacements for them could be trained. The aborigines, numbering approximately 150,000, are Kaosha tribespeople. They speak various dialects and live as hunters or unskilled farmers in the hills. The Chinese, who comprise the remainder of Formosa's population, are mostly descendants of the original settlers from Fukien and Kwangtung.

AGRICULTURE IN RELATION TO INDUSTRY

Agriculture is the dominant element in Formosa's economy, since agricultural activities engage more than half of the population. From the standpoint of industrial development, agriculture is important not only because it feeds the people but also because agriculture supplies some of the raw materials of industry.

Of the total land under cultivation a little over one-half normally is devoted to rice. Rice is the great food crop and often is available for export as well. Most of the remainder of the arable land is in sugar cane plantations. Sweet potatoes, a food crop, and tea, pineapples, and bananas for export are other important elements of the agricultural picture.

INDUSTRIES OF FORMOSA

When the Chinese took over in September, 1945, the total number of industrial units in Formosa with capital of more than 50,000 yen (at the pre-war rate) was over 1000. Prominent among these were the power industry, sugar refining, the pulp and paper industry, cement making, petroleum refining and fertilizer manufacture. Two aluminum plants and two caustic soda plants were also represented.

The industrial structure of Formosa is built chiefly upon an abundant supply of hydroelectric power. Coal, used in auxiliary steam plants, is a much less important source of energy. The availability of low-cost power in conjunction with adequate raw materials for the industrial plants established throughout the island has made possible most of the present industrial development.

Power Industry

The total capacity of all power plants constructed by the Japanese in Formosa up to 1945 was 321,100 kilowatts, 80 per cent being hydroelectric and 20 per cent steam power. With the exception of 55,000 kilowatts installed at Hualienchiang on the isolated east coast, all plants are an integral part of the main network extending from north to south along the west coast and serving all major industrial and agricultural areas. The main units are established near the geographical center of the island adjacent to the only reservoir area, the combined Sun Moon Lake, at a height of some 2400 feet above sea level. The union of these two lakes was made by means of a single master dam, raising

the level of the two lakes some 120 feet. The water is fed by an ingenious system of tunnels approximately eleven miles in length through the surrounding mountains to three main stations producing a total of 159,000 kilowatts, the largest of these plants generating 100,000 kilowatts from a 1000-foot head. These central plants are linked with seven primary sub-stations from Keelung in the north to Kaohsiung in the south.

Power facilities suffered heavily from Allied bombing, some units being almost completely demolished. The damage can be gauged by the fact that only 40,000 kilowatts were available when China recommenced operations. The work of rehabilitation was extremely difficult, due to lack of materials and equipment. Portions of damaged plants had to be used to refit main sub-stations, while undamaged installations were transferred from sub-stations to the central plant at Sun Moon Lake. Power supply was uninterrupted while these changes were being made, and generating capacity was doubled in less than a year's time. Total available hydroelectric capacity is now 237,000 kilowatts.

Generating capacity can be further increased without too great capital investment. The Japanese had planned, and partially completed, additional plants designed to add 300,000 kilowatts, and it is estimated that power could be eventually developed to 2,500,000 kilowatts.

Sugar Industry

The sugar refining industry of Formosa has been developed over a period of some 40 years and had reached an annual production of 1,500,000 tons of sugar in its best year (1938). Annual average production for the nine-year period 1936–44 was 1,200,000 tons. At the time of the Chinese occupation of the island in 1945, there were 42 sugar factories of which 31 produced direct consumption sugar (75 per cent of the total output) and 11 made raw sugar.

As a result of the war demand for alcohol, several sugar plants were converted to alcohol production and had a total output of 18,000,000 gallons in 1943, but they became a priority target for bombing, the result being almost total destruction. Company railroads were damaged to the extent of 35 per cent. War conditions also interrupted the cane planting program and reduced the fertilizer available for sugar cane to a negligible amount, curtailing the supply of cane for grinding. As a result only 17 plants operated during the 1945–46 season and production was less than 90,000 tons.

The Taiwan Sugar Corporation chose 36 plants for continued operation, and post-war restoration progressed rapidly. Production for the 1946–47 season was 300,000 tons, of which 100,000 tons were earmarked for export. The sugar corporation owns 247,000 acres of land (valued at $200 per acre) which supplies about one-third of its cane requirements. The balance is produced by independent growers. A company railway system serves the entire cane area. Fifteen hundred miles of narrow-gauge lines connect plantations, factories, and ports, and a telephone system is operated in conjunction with the railroads.

Pulp and Paper Industry

The pulp and paper industry was an outgrowth of the sugar industry. To 1,500,000 tons of sugar there are more than 2,000,000 tons of waste sugar cane, or bagasse, and it was the abundance of bagasse that led to the development of the pulp and paper industry in Formosa.

There are seven paper factories on the island. In these seven factories there are eight Fourdrinier machines and

eleven cylinder machines, including press molds for wallboard. The rated capacity of two of the largest machines designed to produce pulp from bagasse is 48,000 tons of pulp per year. Maximum production did not reach this figure, however, and during the war all the paper mills were damaged by bombing, so that considerable further investment would be required before the industry could operate at capacity.

China was nevertheless fortunate in inheriting, with Formosa, facilities equal to a third of the total modern paper-making machinery in China. Furthermore, Formosa has the best resources of any region in China, with the possible exception of Manchuria, for producing paper. Restoration work is being carried on, and production has almost reached pre-war levels.

Cement Industry

There are three cement plants on Formosa. The Suao plant is located one mile from the town of Suao in the northeastern part of the island, with a harbor capable of taking up to 5000-ton vessels. This plant was completed in 1943. It is a dry-process plant with a capacity of 3800 barrels per day. The Kaohsiung plant, in southwestern Formosa, is the largest of the three and is capable of producing 8000 barrels per day. It was originally put into operation in 1917 and has been continually enlarged and modernized, producing Portland cement since that time by the dry-process. This plant has access to the splendid harbor of Kaohsiung taking ocean-going vessels. The Tsutung plant is located near Hsinchu on the northwestern coast of the island. It is a new and very modern plant, completed in 1946. The railroad connecting it with Hsinchu was completed early in 1947. This plant uses the Lepol kiln process and has a capacity of 2000 barrels per day.

The Suao and Tsutung plants were heavily bombed during the war and were badly damaged. The Kaohsiung plant suffered less damage, being close to a large mountain which deflected the bombs. An American engineering firm was engaged by the National Resources Commission to furnish materials and equipment as well as engineering services. Restoration work was finished shortly after January, 1948, and the cement industry is rapidly stepping up operations. In May, 1946, output was at the rate of 64,000 metric tons annually; in October of the same year the rate had reached 120,000 metric tons. Present production is at the rate of 682,000 metric tons per year compared with 293,780, the highest annual output achieved by the Japanese, in 1943.

The cement industry on Formosa enjoys numerous advantages: large, high-grade deposits of limestone, silica sand available at plant sites, cheap coal mined locally, low power rates, and transportation by both water and rail.

The Petroleum Industry

The Kaohsiung refinery was rehabilitated from the remnants of the former No. 6 Fuel Station of the Japanese Navy which was uncompleted and had been heavily damaged by the American Air Force during the war. The refinery is situated in the suburbs of the city of Kaohsiung and is served by the port of Kaohsiung, to which it is connected by a 10-mile pipeline. Storage capacity totals 900,000 barrels, equally distributed between the terminal and the refinery.

The Kaohsiung refinery is owned and operated by the Chinese Petroleum Corporation, which from its district office located at Taipei, the capital, supplies the province with 550,000 gallons of gasoline, 200,000 gallons of kerosene, 500 tons of Diesel oil, 3000

tons of fuel oil, and 50,000 kilograms of lubricants per month. All these supplies, except lubricants, come from the Kaohsiung refinery. White stocks are distributed to various point on the island by tank cars along the railroad lines, and black stocks to Keelung by water. Keelung terminal has seven storage tanks and two warehouses, with a total capacity of 71,740 barrels. There are nine supply stations at various towns throughout the island and also service stations for local distribution.

Products of the Kaohsiung refinery also go to the China mainland where the Chinese Petroleum Corporation has eight other district offices supervising marketing and distribution in surrounding areas: Shanghai, Canton, Nanking, Tientsin, and so on. An affiliate of Chinese Petroleum Corporation, the China Tanker Company, owns and operates 18 coastal tankers of the T-1 type and four ocean-going tankers ranging in tonnage from 10,000 to 15,000 tons. The ocean-going tankers carry crude oil to Formosa from the Persian Gulf, the small tankers transship bulk stocks to coastal cities.

The Formosa refinery is not entirely modern and up-to-date judged by American standards. It has, nevertheless, succeeded in producing the fundamental petroleum products for the Chinese market, and the petroleum industry has been considerably extended by the Chinese since the take-over from Japan.

The Fertilizer Industry

Formosa has three fertilizer plants in operation at present and a fourth plant newly completed. One plant producing 60 tons of superphosphates and 40 tons of sulphuric acid per day and another making 20 tons of superphosphates are located at Keelung. The third operating plant, producing 60 tons of calcium carbide and 40 tons of cyanamide per day, is at Kaohsiung. The fourth plant soon to go into operation will manufacture calcium carbide at the rate of 80 tons per day. The combined output of these four plants will fulfill Formosa's needs in respect to phosphates, production of which already exceeds the output attained by the Japanese. In respect to nitrogen and potash, however, Formosa suffers from a serious shortage. It must import these fertilizers until a nitrogen-fixation plant, now in the planning stage, can be constructed.

TRANSPORTATION, HARBORS AND DOCKS

The island's transportation is well equipped to serve industry. There is first of all an excellent railway system. A standard-gauge line approximately 500 miles long extends from the port of Suao on the northeast coast via the principal cities of Keelung, Taipei (the capital), and Tainan (the main industrial area in the center of the island) to the southern port of Kaohsiung, connecting the large industrial and port areas. Rolling stock deteriorated during the war, and considerable investment is required for necessary replacements. An 11,500-mile network of motor highways serves the main cities and towns. These highways were built by the Japanese who provided good roadbeds and wide, well-drained surfaces. Repair work of war damage has been largely completed.

Formosa is also well equipped with ports. Keelung at present serves as the main port of entry and export. In spite of war damage, excellent service is being provided for ships up to 15,000 tons. Keelung has berths for 35 large and small ships. Vessels drawing up to 30 feet can be discharged to the terminal without lighterage. Kaohsiung, the second largest deep water

port of the island, has one of the finest harbors in the Far East. It was the main bombing target during the war and suffered greater destruction than any port of its size other than Manila and Yokohama. Much of the warehouse accommodation has now been rebuilt, and some 17 wrecks have been removed from the harbor. Kaohsiung harbor has 19 wharves, most of which have been restored to service, and an additional wharf is being constructed, scheduled for completion in 1948. The channel to the harbor has a depth of 33 feet except for a stretch of 300 feet, but the shallower part is 27½ feet deep and readily admits ships of the 10,000-ton class.

The Japanese built an airport on Formosa which further extends the island's importance in respect to transportation and communication facilities.

ECONOMIC DEVELOPMENT UNDER CHINESE ADMINISTRATION

When the Chinese Government took over in Formosa in September, 1945, it was found that destruction ranged from 25 to 100 per cent and all industrial operations were at a standstill. Rehabilitation was hampered by the repatriation of Japanese technicians and workers, as there were not enough trained Chinese personnel to replace them. Another difficulty was the fact that many damaged machine parts could be replaced only by the original Japanese makers. Facilities that had escaped bombing had suffered from neglect and depreciation and the inability of the Japanese to replace worn parts and furnish operating supplies.

Fortunately for Formosa, the Chinese Central Government dispatched to the island a hand-picked group of key engineers, trained in the United States and Europe, who proceeded with the rapid and efficient reconstruction that is now plainly evident. The solution of technical problems, as well as comprehensive problems of industrial organization, had been planned in detail.

Reorganization of confiscated Japanese industry was effected by setting up 46 official and semi-official companies comprising 412 factory units which embraced all important phases of economic activity. Of these 46 companies, three are under the exclusive control of the Central Government; the remainder are under joint management of the Central Government and the Provincial Government. Some 400 small enterprises and single factory units were offered for sale or lease to private traders, but the extent of independent capital management is of minor importance in the overall economic sense. Emphasis has been placed on a state-controlled economy, probably to the extent of 90 per cent.

The labor situation is acknowledged to be good in Formosa. The labor pool is more than adequate, and the average Formosan worker is literate, industrious, interested in machinery, and adaptable to new techniques. Wage statistics are lacking, but it is known that in February, 1947, the average unskilled worker was paid the equivalent of two United States dollars per day. This may be taken to indicate a fairly satisfactory standard in relation to the general economic level of the island.

The cost of living in Formosa has been consistently less than half of that in China proper. Although there has been some inflation, prices have remained quite reasonable and the currency relatively stable. The Formosan yen was retained as the unit of currency, and the monetary system has been operated independently of that on the Chinese mainland, although until January, 1948, the yen was pegged to the Chinese dollar. At that time the For-

mosan Government was given authority to adjust the exchange rate and Formosa's currency was deliberately overvalued, a policy which was to the island's advantage during the severest period of unbalance in China proper. A realistic level was established for Formosa when the Chinese Government instituted the managed gold standard currency on August 19, 1948. The present exchange rate between Chinese currency and Formosan notes is 1 to 1835 (for an indication of the relatively small degree of inflation in Formosa, compare the conversion rate of the old Chinese dollar to the new gold yuan, i.e., 3,000,000 to 1).

FORMOSA'S INDUSTRIAL PROSPECTS

The present position of industry in Formosa has its good and bad aspects. The island's assets are (1) low-cost hydroelectric power, (2) thousands of Formosan laborers trained in mechanical skills, (3) availability of cheap transportation by water, and (4) proximity to important Far Eastern areas. Balanced against these assets are the absence of native capital for investment purposes and also the necessity for importing basic raw materials if heavy industry is to be developed.

Formosa's future is, of course, dependent upon the island's treatment by China. Will the industrial plant inherited by the Chinese be turned to the benefit of the Formosans? It is evident that Formosa can ultimately be an asset to China only if given favorable conditions for development. Chinese policy in Formosa will be the determining factor.

PRODUCTION AND UTILIZATION OF THE SOYBEAN IN THE UNITED STATES

Alvin A. Munn

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THE rapid growth of soybean production in the United States has been one of the most striking agricultural developments in recent times. Between 1924 and 1945 the acreage planted in soybeans in the United States increased eightfold from about 1.8 million acres to 14.2 million acres. This rise in production has been encouraged by the adaptability of soybeans to mechanized farming, their position in the seasonal distribution of labor, their profitableness as a cash crop, and continual research aimed at improvement of both their quality and usefulness. As a result, soybean products—oil and meal—have been developed for widespread utilization in foods, livestock feeds, and industrial products.

Trends of Production in the United States

In the United States in 1945, 10.9 million acres of soybeans (191.8 million bushels) were harvested for use as beans while 2.1 million acres of soybeans (2.7 million tons) were harvested for hay. The first peak in the rise of soybean acreage in the United States occurred in 1935 when over 7.5 million acres of soybeans were planted (Fig. 1). This increase has been attributed to the program of soil conservation sponsored by the Agricultural Adjustment Administration of the United States Department of Agriculture. Soybeans, when turned under as a green manure, are classed as a soil-conserving crop. Many farmers planted soybeans for a soil-conserving crop as a result of the influence of federal, state, and county agents, and program disbursements. The second peak in acreage came in 1940. During this year the soybean acreage harvested for beans was 4.7 million; 4.8 million acres were harvested for hay; and 2.1 million acres were grazed, plowed under, or abandoned. This increase was stimulated by the outbreak of World War II, and the prospect for increased exports of soybeans. Acreage planted in soybeans in the United States reached an all-time high in 1946. The Department of Agriculture was aware of the increased need for vegetable oils and urged farmers to expand oil-seed production. Increased soybean production was also considered essential to build up a supply of protein which would be readily available if meat production dropped below critical levels.

Much of the expansion that has taken place during the last five years can be attributed to the great need for vegetable fats and oils during the war and the

government support price of $1.60 per bushel in 1942. This price was approximately double the price that had prevailed during the immediate prewar year. The farmers responded quickly to the government's request for increased acreage, and in 1942 production and acreage nearly doubled the 1941 figure. The government, in order to follow through its price support commitment, offered loans to farmers, bought from farmers, and bought from elevators. It also contracted with the processors for payment of not less than support prices for all soybeans purchased. Yearly increases in the support price have been made and in 1946 the base support price was $2.04 per bushel. During all the war years the government incurred substantial losses in carrying out its price-support program. Over the four-year period subsidies involved approximately one hundred million dollars. Today the soybean industry is being released from government control. Processing contracts, set-asides, and limitation orders are rapidly being terminated. This period

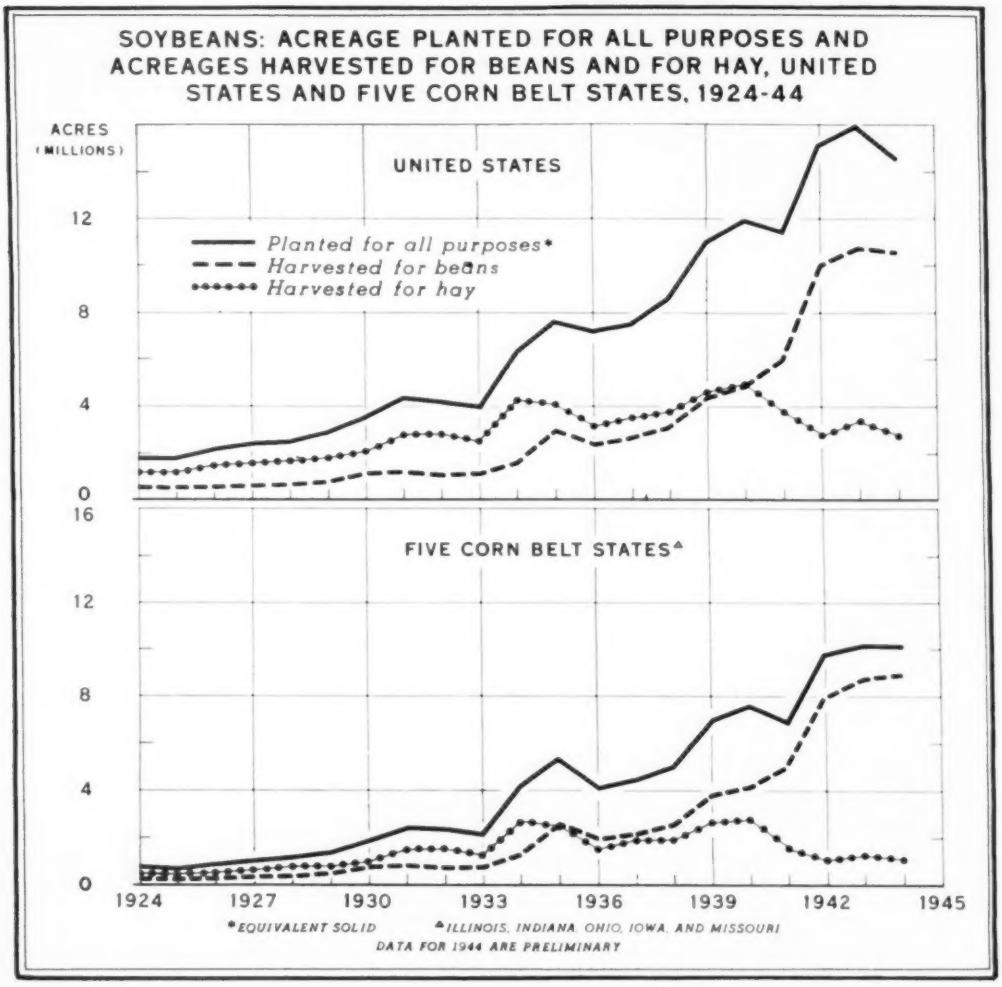

FIG. 1. Peaks in soybean acreage were reached in 1935 and 1940, but the all-time high was not attained until 1943. (From Bureau of Agricultural Economics, U.S.D.A.)

has seen many changes and improvements through research and experimentation that have resulted in marked progress in this new industry.

REGIONS OF PRODUCTION IN THE UNITED STATES

Although, through research, the soybean has been adapted to various combinations of soil and climate, production in the United States seems to follow a distinct pattern. For purposes of this study the United States has been divided into three regions of production. The largest region will be called the North Central Region, the second largest region the Central Mississippi Lowlands, and the smallest region the Middle Atlantic Coast.

The North Central Region

This region includes the states of Illinois, Indiana, Ohio, Iowa, and Missouri. It is the Corn Belt plus adjacent areas to the north and south. This region is the largest area of production of the soybean in the United States. During the last 10 years from 85 to 93 per cent of all the soybeans in the United States have been produced in these five Corn Belt states (Fig. 2). Illinois has the heaviest concentration of soybean cropland. The rate of increase or expansion in this region exceeded that in either of the other regions and closely paralleled that of the entire United States (Fig. 3).

Soybeans grew in relative importance in the North Central Region, not as a result of reduction in other parts of the country but because of their rapid rate of expansion in this region. Representatives of the United States Department of Agriculture assigned posts at various experimental stations scattered throughout this North Central Region did much to improve the quality of soybeans. Farmers were also looking for a crop that would be nearly interchangeable with corn, a crop that would

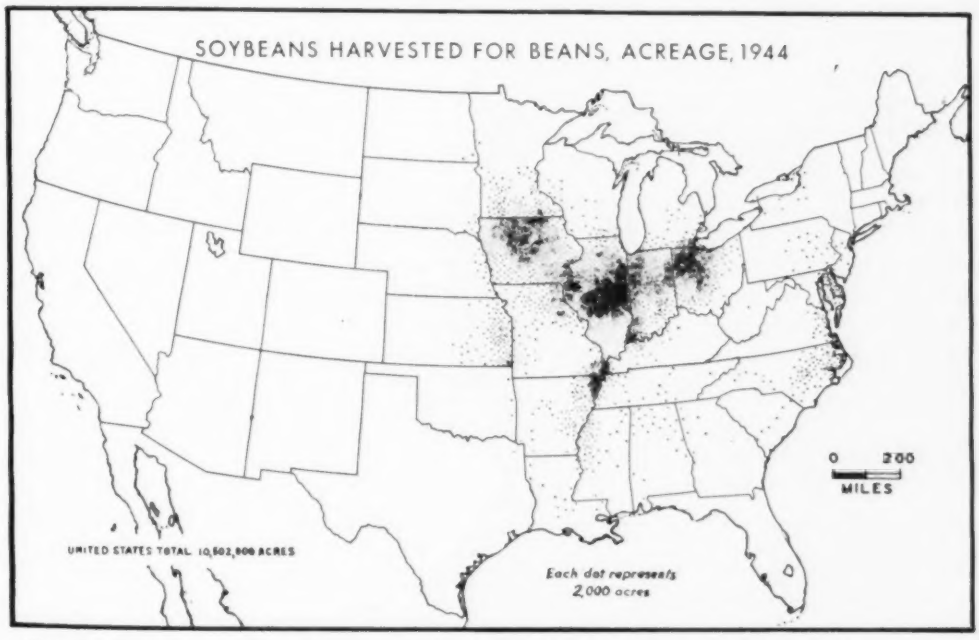

FIG. 2. The pattern of soybean production in the United States emphasizes the importance of the Corn Belt states. (Bureau of Agricultural Economics, U.S.D.A.)

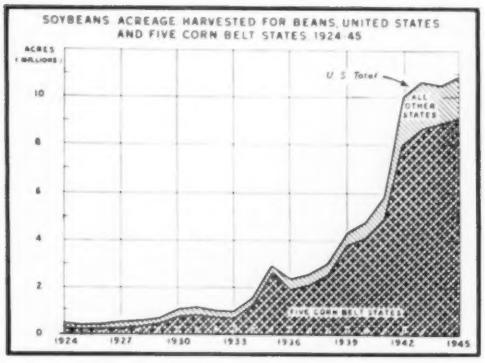

FIG. 3. The increase in soybean acreage in the five Corn Belt states has exceeded that in any other part of the United States. (Bureau of Agricultural Economics, U.S.D.A.)

sell for prices high enough to make worth while its production in the years when corn prices were low. American vegetable oil supplies were drastically reduced due to the widespread effects of World War II, and the government urged production of the soybean to offset this shortage.

The Central Mississippi Lowlands

Included in this region are the states of Arkansas, Mississippi, and Louisiana. This area is considerably smaller than the North Central Region and soybean cultivation appears to be confined to the areas that are close to the Mississippi River. Previous to World War II soybeans were grown in this region primarily for hay and soil improvement, but this was changed somewhat with the increased need for vegetable oils. Soybeans are well adapted to the climate of the Central Mississippi Lowlands and do well on many southern soils. One of the major handicaps was the small number of combines in the region. This factor is gradually being overcome through coöperation of farmers in the utilization of equipment. Numerous cottonseed mills scattered throughout the region offer excellent soybean processing facilities. The relatively high price of the beans and the limitations of cotton acreage have been instrumental in increasing soybean production.

The Middle Atlantic Coast

Soybean production in the Middle Atlantic Coastal states of North Carolina, Virginia, Maryland, and Delaware has not experienced the rapid rise in production characteristic of the North Central Region. This is the smallest of the three soybean-producing regions. Acreage is heaviest in the southeastern tip of Virginia and the northeastern tip of North Carolina. Retarded development has been attributed to the lack of adapted varieties suitable for bean production and the adverse weather conditions during the late fall and early winter that hinder harvesting.

Soybeans have been used primarily as a hay or forage crop in this region since 1924, with an approximate average of only 35 per cent of the total acreage being harvested for beans.

FACTORS IN THE LOCALIZATION OF PRODUCTION IN THE UNITED STATES

The soybean is grown in a wide variety of soil and climatic associations, but at present it is limited to areas with a long growing season, or approximately the Corn and Cotton Belts. Ideal growing conditions call for continued good weather in October and November so that the crop can be harvested readily without too much danger of severe storms or snow.

The critical factor in the localization of production of the soybean appears to be the type of farming in the particular area. Soybeans yield profits best on large mechanized farms. For this reason they fit well into the Corn Belt scheme of agriculture. In the Corn Belt soybeans serve as livestock feed and as a replacement for corn. Growing of soybeans in the Dairy Belt is limited by shortness of the growing season,

paucity of mechanical equipment, and opposition by butter interests. Much of the Cotton Belt is lacking in equipment. Although the Wheat Belt has large mechanized farms it generally is too dry for production of the soybean.

Soybeans are sometimes sown with corn but are commonly grown separately in a regular rotation system in the major regions of production in the United States. In general the farmers use the same methods in planting and cultivating soybeans as in the production of crops they have already been growing. No one time is known at which soybeans can be cut with good yields of both hay and bean crops. If the soybean is to be used as a green vegetable, harvesting can be at time of maturity. Harvest for beans attains its greatest yield when the pods are fully matured. Livestock seem to prefer the hay before maturity approaches as it is more tender and readily consumed at that time. Harvesting the soybean for use as a vegetable is usually by hand. The combine is used extensively in harvesting the bean crop and the mower for cutting the hay crop. After harvesting, the soybeans move through well-established trade channels to central markets and from there to the processing mills.

TABLE I

SOYBEANS CRUSHED IN THE UNITED STATES, 1935–44*

Year beginning October	*1,000 bushels*
1935	25,181
1936	20,618
1937	30,310
1938	44,648
1939	56,684
1940	64,056
1941	77,131
1942	133,454
1943	142,306
1944	153,402

*Source: U.S.D.A., *Agricultural Statistics 1946* (Washington: Government Printing Office, 1946), p. 146. (Computed directly from original data, given in tons.)

THE SOYBEAN THROUGH THE MILL

During the period from 1935 to 1944 soybean mills crushed a rapidly increasing quantity of soybeans. The total number of bushels of soybeans crushed in the United States increased from 25.2 million bushels in 1935 to 153.4 million bushels in 1944 (Table I). The stimulus given to the soybean industry by World War II is particularly evident in the rapid increase in production between 1941 and 1942.

There are only three methods commonly used to process the soybean for oil and meal: the expeller pressure, solvent extraction, and hydraulic pressure methods. Oriental processors crush nearly all their soybeans by hydraulic pressing or some crude form of manual hydraulic pressing. In Europe the solvent extraction method is used almost exclusively. The expeller process is generally used in the United States, although all three processes are employed. The importance of the solvent extraction method in the United States increased during recent years, and a high percentage of the new plants and those still under construction are of this type. The American mills that use hydraulic presses have been engaged primarily in crushing other oilseeds such as cottonseed or linseed. These mills can be adapted to soybean crushing very easily, but usually their operations are more expensive, because of increased hand labor in changing from one batch to another. In 1940–41 the expeller method accounted for 74 per cent of all soybeans crushed in the United States, the solvent method 23 per cent, and the hydraulic only 3 per cent. In 1939–40 the total tonnage of soybeans processed by the hydraulic method decreased sharply. The high recovery of oil made possible by the solvent extraction method is one of the reasons for its popularity. In 1946 several processors were changing their

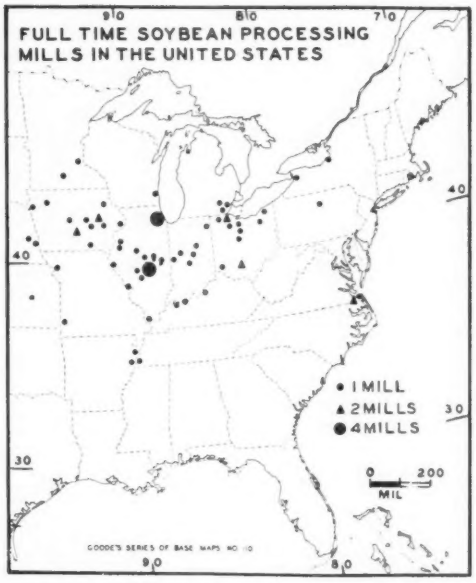

FIG. 4. Distribution of the mills in the United States that specialize in soybean processing, January, 1944. Seventy-two mills are shown on the map and there is another in the San Francisco Bay area. (Data from "Soybean Chemistry and Technology," Klare S. Markley and Warren H. Goss, New York, 1944.)

equipment from expeller to solvent types.

CONSUMPTION OF SOYBEAN PRODUCTS

The versatility of the soybean is evident from the manner in which it is consumed. Four main products which will be treated in the following pages are: soybean oil, soybean oil meal, lecithin, soybean flour. The most common processing of soybeans results in two products: soybean oil and a residue by-product oil meal (or cake). Lecithin is obtained from specially treated soybean oil. Soybean flour and soybean milk may each be made from whole soybeans in processing producing no major by-products. Soybean oil and its products are used both for food and for industry. Soybean oil meal is processed for use as animal feed, industrial protein, fertilizer, and grits. Lecithin is an extremely adaptable substance that serves as a carrier and preservative and has found wide usage. Bakery goods and foods are produced from soybean flour. Soybean milk is used in cheese production.

Soybean Oil

Soybean oil has become important in the United States only during recent years. It first attained commercial importance during World War I when large quantities were imported (mainly from China and Japan) to replace oils and fats exported to Europe. These imports reached a peak of 336 million pounds in 1918, but following the war they decreased sharply to 196 million pounds in 1919 and 17 million pounds in 1921. The Tariff Act of 1930, which increased the import duty on soybean oil from 2.5 cents to 3.5 cents per pound was influential in decreasing the imports. During the period from 1930 to 1934 imports were relatively small (Table II). In 1935 and 1937 an increase in imports took place because of the reduced domestic production and supply.

Generally the quantity of soybean oil utilized in industry increased steadily from 1931 (Table III). In 1941 at the outbreak of World War II the consumption of soybean oil in the drying and soap industries was sharply curtailed. At this time government supervision of both production and industry channeled larger quantities of soybean oil into the food products industries in order to diminish the possibility of drastic shortages of essential fats and oils. As a result the amount of soybean oil used in the production of shortening increased from 216.1 million pounds in 1941 to 620.2 million pounds in 1944. Consumption of soybean oil by the margarine manufacturers increased from 75.6 million pounds in 1941 to 211.1 million pounds in 1944. Greater quantities of soybean oil were made available for use in other food products at this time,

although this increase in consumption was slightly under 100 per cent.

TABLE II

SOYBEAN OIL:
SUPPLY IN THE UNITED STATES, 1924–44*
(thousands of pounds)

Calendar Year	*Stocks Jan. 1*	*Domestic Production*	*Imports for Consumption*	*Domestic Supply*
1924	9,451	950	8,848	19,249
1925	2,836	2,520	17,745	23,101
1926	2,458	2,646	30,167	35,371
1927	7,723	3,088	13,731	24,542
1928	6,291	4,716	12,264	23,271
1929	6,073	11,009	19,360	36,442
1930	15,631	14,387	7,831	37,849
1931	15,178	39,150	4,018	58,346
1932	18,650	39,445	359	58,454
1933	16,552	26,533	3,669	46,754
1934	13,534	35,366	2,829	51,729
1935	19,607	105,056	14,249	138,312
1936	31,090	225,297	4,217	260,604
1937	34,416	194,411	22,259	251,086
1938	62,317	323,343	2,856	388,516
1939	76,709	457,550	4,126	538,385
1940	71,562	533,224	4,849	609,635
1941	94,555	585,629	759	680,943
1942	113,020	761,582	0	874,602
1943	144,139	1,233,751	0	1,377,890
1944	186,566	1,235,806	103	1,422,475

*Source: Edwin G. Strand, "Soybean Production in War and Peace," U.S.D.A., Bureau of Agricultural Economics (Washington, 1945), p. 23.

Exports of soybean oil increased from 12.0 to 65.4 million pounds during the 1941–44 war period.

Soybean oil has many qualities that make it adaptable to a wide variety of uses. As indicated by Table II the domestic supply of soybean oil in 1944 was 1,422 million pounds of which 620 was used in shortening, 211 in margarine, 279 in other edible products, 19 in drying industries, 3 in soap, and 31 in other industrial uses; thus nearly all the soybean oil is utilized in edible products. Oil that is to be employed in the manufacture of edible food products required extensive refining, deodorizing, decoloring, and hydrogenating.

Food Products.—It has been estimated that over fifty different food products containing soybean oil are manufactured in this country; the principal food uses of soybean oil in order are for shortening, margarine, and salad dressing and mayonnaise. There are three major types of final products in which edible oil is used: shortening type oils, sharp melting solid fats, and liquid salad oils. There has been a marked increase during recent years in the relative importance of soybean oil in the production of edible products.

Shortening had been made almost wholly from animal fats until during the 1920's when cottonseed and peanut oils began to be used. Skillful technicians worked on the processing of soybean oil, and when it became clear that it could be hydrogenated to produce a crystal white vegetable shortening no time was lost in getting it on the market. In 1944 over 44 per cent of the nation's soybean oil production was being used for shortening. During the war the amount used in shortening was tripled.

In 1930 the Staley Manufacturing Company sold the first tank of refined soybean oil to a manufacturer of margarine. The oil gave the margarine a rich, butter-like color. This was immediately pounced upon by dairy interests and after much pressure restrictive laws were enacted. Though these restrictions have been severe they have not succeeded in stopping the increase in the popularity of margarine. This has been called a case of the American farmer working against himself. Soybean oil is a product of the farm, and if margarine restrictions were removed a much wider market would be opened to soybean growers, cotton farmers, growers of peanuts, and corn as well as the raisers of hogs.

Recently an all-vegetable product named soya butter, manufactured by Butler Food Products of Cedar Lake, Michigan, of soybean oil and other soybean derivatives with added carrot oil to give it a bright yellow color has

TABLE III

SOYBEAN OIL: UTILIZATION IN THE UNITED STATES, 1924–44*
(thousands of pounds)

Calendar Year	*Shortening*[a]	*Margarine*	*Drying Industries*[b]	*Soap*	*Exports*[c]	*Carryover Dec. 31*
1924					2,264	2,836
1925					520	2,458
1926		Not reported before 1931			1,567	7,723
1927					5,444	6,291
1928					7,142	6,073
1929					7,967	15,631
1930					4,962	15,178
1931	10,869	622	8,901	3,816	4,551	18,650
1932	4,889	3	11,593	5,571	2,647	16,552
1933	489	7	14,274	4,235	1,569	13,534
1934	2,735	24	13,353	1,354	2,040	19,007
1935	52,452	1,740	17,871	2,549	4,111	31,090
1936	113,897	14,261	17,419	5,023	3,954	34,416
1937	90,798	31,791	17,157	10,274	5,748	62,317
1938	137,133	39,885	18,847	10,897	6,412	76,709
1939	201,599	70,822	28,220	11,177	12,111	71,562
1940	212,317	87,103	37,164	17,612	15,954	94,555
1941	215,967	75,634	49,515	24,737	12,066	113,020
1942	335,555	133,346	25,928	21,510	19,428	144,139
1943	568,405	198,020	20,783	15,428	57,351	186,566
1944	620,257	211,105	19,176	3,258	65,422	121,897

*Source: Edwin G. Strand: "Soybean Production in War and Peace," U.S.D.A., Bureau of Agricultural Economics (Washington, 1945), p. 23.

[a] Compounds and vegetable cooking fats.

[b] Includes paints and varnishes, linoleum, oilcloth, and printing inks.

[c] Exports from domestic production and stocks. Does not include re-exports.

been introduced. It has met with a barrage of federal and state rulings that have seriously hampered its sale.

The story of the use of soybean oil for salad dressings and mayonnaise is quite like that of shortening. The product came into wide usage after many months of experimentation and research. Today it is used throughout the United States and its quality and excellence are widely praised. More recently soybean oil refined as an edible oil has been used as a frying or cooking oil for meat, fish, vegetables, and as a fresh vegetable oil for salads.

Industrial Products.—The use of soybean oil in industry has lagged behind its use in food. The drying industries consumed the largest amount of soybean oil in 1940. Soybean oil is a semi-drying oil with an iodine number of about 135 compared to 110 for cottonseed oil or 180 for linseed oil. Since that year consumption has been lower because of the demands and restrictions placed on the usage of fats and oils during World War II. With the release of these controls it is expected that soybean oil will again find greater usage in industry.

Soybean oil was first used in the United States in the manufacture of soap. During World War I most of the imports went into soap and the remainder was used in the manufacture of paint, varnishes, and explosives. The quantities used in the drying and soap industries during the recent war were considerably larger than before 1938 (Table III).

Soybean oil is especially adapted to soap manufacture because of its frothing powers. Substantially all soybean oil used in soap, in the past, has been used in the United States in liquid soaps. Liquid soaps constitute a minor volume

of the total soap production. With the perfection of more advanced methods of hydrogenation the use of soybean oil in soap making is expanding.

To utilize soybean oil in the drying oil industries the problem is one of converting semi-drying oil to a product with drying properties. Many methods of doing this have been tried; many of them apparently are technically and economically sound. Solvent separation and fractional distillation produce a drying fraction suitable for many types of industrial applications. These separation installations require elaborate equipment. This oil contains excellent color stability, and has rapid drying characteristics. For these reasons it has won special favor with the manufacturers of paint, varnish, synthetic resins, protective coatings, linoleum, and printing inks.

The use of soybean oil by the automobile industry, particularly the Ford Motor Company, has long been a subject of publicity. At this time the Ford Motor Company does not appear to be actively participating in this field. The 1942 Ford automobile had over twenty soybean plastic parts. Other uses of soybean oil by Ford were in soft soaps, paints, enamels, and in glycerine for shock absorbers.

Soybean oil has been found superior to corn and cottonseed oil in the manufacture of foundry cores. The oil when used for this work is commonly referred to as core oil. It has an advantage over linseed oil or mineral oil in possessing emulsifying properties which are desired in core oil.

There are numerous other industrial uses of soybean oil. It has special qualities that aid in the composition of waterproofing cement and orchard sprays. In waterproofing cement the non-drying fats and oils of the soybean provide a lasting effect. Soybean oil is a good sticker and spreader when used in orchard sprays.

Soybean Oil Meal

The exact type of soybean oil meal that is obtained from milling the soybean depends upon the process that has been used. If the processing has been done by the solvent extraction method a sort of flake is produced, but if the expeller or hydraulic pressure method has been employed a cake type of product is obtained. The flakes contain less than 1 per cent oil while the cake contains as much as 4 per cent.

Animal Feeds.—The past ten years have seen a rapid increase in the utilization of soybean oil meal as a high protein concentrate feed for animals and poultry. Approximately 95 per cent of the soybean oil meal produced is used in poultry and livestock feeding. Today's high consumption of soybean oil meal for animal feeding was given impetus by World War II. A tremendous increase in livestock numbers, and an even greater demand for increased meat production has done much toward popularizing the use of soybean oil meal. Many tests have been made, and authorities apparently agree that soybean proteins are more digestible than other proteins of vegetable origin.

Processed soybean oil meal supplement corn and other grains as livestock feeds. The oil meal is rarely fed separately in the ration but is usually processed and contains other ingredients. This proportion of oil meal in a mixed diet does not exceed about 1 part soybean oil meal to 4 parts corn.

Dairy cattle consume most of the soybean oil meal produced. In the feeding of lambs soybean oil meal may replace all the corn. In a lamb feeding experiment those receiving all soybean oil meal, and no corn, daily gained

weight more rapidly than those fed a mixture of corn and meal.

Hogs belong to the class of critical animals that require protein of high quality for maxim development. Better weight results, from both the economy and time viewpoint, have been attained by combining soybean oil meal with other feeds as a supplement to grains for hogs.

The poultry industry has done considerable pioneering in the use of soybean oil meal as feed. This has been successful because of the high prices of animal protein, and the relatively steady poultry population. Poultry experts have found that the usage of soybean oil meal in the feed combinations has promoted optimum growth, egg production, and reproduction. The advantage that soybean oil meal has over some other plant concentrates lies in its quality of not influencing the color of the egg yolk.

It is estimated that over half of the 15,000,000 dogs in the United States are fed primarily canned or dry dog feeds. Processed soybean oil meal products are used in feeding dogs, cats, furbearing animals, and even fish.

Industrial Proteins.—During the past years many methods have been worked out for the manufacture of isolated protein. Usually the starting point is a specially prepared soybean meal from which the oil has been eliminated.

Isolated protein is being used in a great many industries in the United States and Canada. The typical uses are as an adhesive or binder for paper coatings and washable wallpaper coatings, binder and stabilizing agent in water paint products, binder in leather finishes, adhesive agent in textile sizes, and a binder in insulating and wall board coatings. Floor covering, emulsions, and adhesives have also recently been placed on the list of uses of soybean protein.

In the spraying of many crops, plants, shrubs, and trees to control insect pests difficulty is often encountered because of the failure of the spray materials to adhere properly to the leaf and other surfaces. An industrial soybean product marketed in the form of a specially processed soybean flour for agricultural sprays has been developed. It is used because of its qualities as a spreader and sticker.

Fertilizers.—The output of soybean oil meal for fertilizers has been relatively small compared with the total fertilizer production figures. During a prewar normal year only 50,000 tons were consumed; during the war the total tonnage was reduced to around 20,000 tons, because of the desire to utilize the meal for feed purposes. Soybean oil meal is a carrier of organic nitrogen, and it has advantages over cottonseed meal, because its nitrogen content is greater and more readily available.

Grits.—In the expeller pressure extraction process the cake is frequently ground into grits. These grits, often referred to as pellets, are sold to the manufacturers of sausage and other pressed meat products. By the use of these grits the meat packer may greatly increase the protein value of his products. The fat content is a minimum of 5.0 per cent, and a maximum of 9.0 per cent. The protein content of grits is a minimum of 48.5 per cent.

Lecithin

Lecithin is a fatty substance formerly obtained from brain tissue, later egg yolk, and now from the soybean. It is one of a group of substances known to chemists as phosphatides. The ordinary commercial soybean lecithin is a complex mixture of lecithin, cephalin, and soybean oil which serves as a carrier and

a preservative. Lecithin is produced by a solvent extraction method of processing the soybean. It is a yellow plastic wax-like mass that darkens on exposure to the air. The lecithin molecule has a split personality. One side prefers fat and the other is attracted by water. It is this unique colloidal and emulsifying property that makes it extremely adaptable and satisfactory for many uses. Lecithin does not generally act as a true solvent, but rather as an absorbent. There are few companies in the United States that produce refined lecithin. The principal one is the Glidden Company of Chicago.

The list of products in which lecithin has found usage is very long. Generally lecithin is used in these products in much smaller quantity than other soybean subsidiaries.

Soybean Flour

It is believed that less than 1 per cent of the soybeans were used in the manufacture of soybean flour (referred to as soya flour commercially) in the years immediately preceding World War II. During the war, manufacture of soya flour was greatly increased, and the quantity produced in 1943 was equivalent to about 3 per cent of the total. A large percentage of this was purchased by the Federal Government for Lend-Lease.

Soya products are ideally adapted for relief feeding purposes because of their high nutritional value. Soya flour is used primarily for human consumption in bakery goods but a small proportion goes into animal feeds.

The main commercial outlet for edible soya flour lies in blends with wheat products. Soya flour lacks gluten and requires wheat as a binder.

Soya flour is prepared from soybean oil meal directly from whole soybeans. The finished flour has a protein content of approximately 51 per cent, and a fat content of about 1 per cent. A less popular type of soya flour has a high fat content. It is ground whole selected soybeans, and contains all the fat or oil of the original soybean. An analysis of this type flour reveals that it contains 40 per cent protein and a minimum of 18 per cent fat. The color of all soya flour is usually a natural soybean yellow. Variations in types and blends of these two flours are found in commercial establishments under various names.

Bakery Goods.—A great deal of experimental work has been done on the utilization of soya flour with wheat flour in bakery products. This has been stimulated by wartime needs for bread by various European countries at a low cost.

The baking industry is constantly increasing its use of soya flour to intensify the nutty flavor of products and defy staleness by maintaining moisture for longer periods. For these reasons some soya flour is generally used in bakeries. It is particularly suitable for inclusion in breads, cakes, muffins, biscuits, pastries, cookies, and crackers.

Soya flour was used by the armies of the leading nations during World War II. The Germans had reserves of it before launching hostilities, and soya flour was used throughout the German army rations. The British next adopted the idea, and made prompt requests for Lend-Lease soya flour from the United States. They incorporated it in bakery products, confections, soup, and large percentages were added to sausage. The United States Army first used soya flour in the well-known concentrated biscuits of the K-ration. Quantities of the flour were shipped abroad to units in the field for use in baking. Since the termination of the war the Quartermaster Corps of the United States Army has been conducting extensive experiments in the

use of soya products to provide more protein for our armies. In addition to the protein and energy values, soya flour contains a high mineral content. It is said to be the cheapest source of calcium of any food product obtainable.

Other Foods.—Soya flour was first introduced in the United States as a health flour in 1926. It had been milled in a preliminary way at first, but by 1935 it had been proven and was an acceptable product for many varied dietary uses. The use of soya flour in health food products, especially those for diabetics, has been notable. Since many food faddists are in favor of a meatless diet these highly flavored soya products won rapid favor in the health food specialty field.

The public school lunch authorities in the United States have found that soya flour can be used, not only satisfactorily, but quite economically in the preparation of soups of many varied flavors. The soya flour industry has also developed a concentrated high soy protein content cereal. It is made by a 50–50 combination of soy flakes and corn grits run through a shredder and toasted. This cereal has a 20 per cent protein content, and its crisp nutty flavor recommends it as an appetizer as well as a decided nutrient.

Soya flour has been widely adapted for use in the manufacture of noodles, macaroni, and spaghetti. The use of soya flour in these instances adds better flavor and higher nutritive values.

The confectionery industry has found that the use of soya flour aids in emulsification of the fats and prevents drying out of the finished candy. It is also helpful in retaining freshness and as an added flavor.

PROSPECTS

The future of the versatile soybean is unpredictable just as its past has been full of surprises. To anticipate soybean production in the years ahead the forces that have been at work in the past must be evaluated. It has been established that this oriental bean prospers and flourishes in the American soil, climate, and system of farming. Progress has been encouraged by extensive research. The industry was stimulated by the crop adjustments resulting from the Agricultural Adjustment Administration programs of the 1930's. The 1942 demands of World War II were primarily responsible for recent increases. The soybean speedily ascended to its position as a major crop in the United States through Government Policy, a critical wartime need for vegetable oils, and the initiative of a small group of pioneers.

By way of conclusion the influences working for and against the soybean may be briefly summed up. Factors that may have a long-range tendency to decrease the acreage of soybeans from the present high level are (1) the availability of increased supplies of other vegetable and animal oils and fats at competitive prices and (2) the removal of government price support. Offsetting these are certain factors that may work in favor of large future acreages of soybeans. Among these are (1) the relative profitableness of soybeans compared with hay or forage, which are alternate crops in a rotation with corn, (2) the probable critical shortage of food, particularly protein, in Europe for several years, (3) the probable progress in the development of higher yielding varieties, and (4) the probable expansion through research of the market for soybeans in foods and in industrial products.

BOOK REVIEWS

GUTHRIE, JOHN A. *The Economics of Pulp and Paper.* xi and 194 pp.; maps, diagrs. Bureau of Economic and Business Research, State College of Washington, Pullman, 1950. Paper bound, $1.50; cloth bound, $2.50. 6 x 9 inches.

Prior to the publication of this thorough but concise study, there has been a singular lack of assembled textual information pertaining to the pulp and paper industry. By gathering together and critically analyzing heretofore scattered and often unavailable economic data, and by accurately portraying the operations of this important North American industry, *Economics of Pulp and Paper* does much to satisfy a long-felt need of economist and geographer alike.

Writing primarily for the economist, the author has approached his study in so unique a manner that many geographers should find it both of immediate interest and an excellent reference book. He makes no attempt to support or disprove existing economic doctrine, and no new theories are proposed. Rather, attention has been focused upon the economic problems and trends of this industry within a well-constructed framework of significant locational factors.

Developed on the theme that "not only the location but also the kind and amount of regional specialization in pulp and paper manufacture depend upon the distribution of forest resources," the study treats every important economic phase of the industry. An ample to excessive amount of quantitative data, including 41 tables and 18 charts, effectively support convincing conclusions as to the many regional and interregional relationships operative within the industry. The seven maps showing production location by types, flow of distribution, and price zones are well drawn and from creditable sources. Following a brief historical introduction in which wood is shown to emerge as the cheapest source of fiber for papermaking and cellulose, a comprehensive yet critical and well-organized analysis is made of each of the following topics: pulpwood supply, manufacturing processes and trends, consumption, international trade, marketing and transportation, prices and price policy, labor relations, wage rates and labor costs, pulpwood and woodpulp costs, regional differences in costs of production, and costs and profits.

The chapters on pulpwood supply and manufacturing processes and trends, in technical accuracy, clarity, and broad definition of terminology, are comparable in excellence to the chapters dealing with the strictly economic aspects. Presenting a clear objective picture of the relation between physical resource and operational technique, they will be read with interest by geographers and should add materially to our knowledge of the distinctive geographic factors affecting this industry. Economic geographers will be interested in the method employed to determine long-term future prospects for the industry. By applying population forecasts to the projected curves of per capita consumption for various grades of paper, estimates of future requirements are obtained. The competitive position of each producing region is then evaluated. The character, accessibility, and growth-drain ratio of its forests, its locational advantages with respect to markets and transportation rates, and its labor and raw material costs, are effectively related to measure the expected degree of regional expansion and specialization.

It seems unfortunate that the author saw fit to place greatest emphasis upon the Pacific Coast region. Canada and Alaska seem to warrant more consideration than is given, while Scandinavia and other world areas are treated only summarily. Except for certain of the later chapters which tend to be top-heavy with statistics within the text itself, the book is both pleasant and easy to read. Its final chapter is a well-developed summary with conclusions. The book forms an excellent basis for further and more intensive studies of the forest industries.

J. A. TOST, JR.

Clark University

WEAVER, JOHN C. *American Barley Production, A Study in Agricultural Geography.* 117 pp.; maps, table. Burgess Publishing Company, Minneapolis, 1950. $3.00. 8½ x 11 inches.

Professor Weaver's admirable study of the historical geography and the present agricultural geography of barley in the United States has been sponsored by the Midwest Barley Improvement Association of Milwaukee, and the Association has copyrighted the book. This connection between a geographer and a business organization is to be commended; it points the way to many other useful and immediate applications of the specialized knowledge of the geographer, and the uses to which American businessmen can apply such knowledge.

The pattern of American barley production from colonial days to the present is traced in 51 excellent maps, accompanied by 63 pages of explanatory text. Initial sections deal with the

barley distributions of the last century—the dominance of New York state in production from 1839–1859, the codominance of New York and California, 1859–1889, and the rise of the Midwest producing centers after 1889. The maps of production are spaced at ten-year intervals from 1839 through 1919, and at five-year intervals from 1919 through 1939; these are followed by an excellent and detailed series of maps showing the location of barley acreage in the North Central States from Michigan to the Dakotas annually from 1939 through 1947. The explanatory text of this section is based on the annual scene, and presents the material for immediate interpretation by the barley growers and businessmen. A series of 18 maps following analyzes in detail many factors in the scene, and orients the grower, miller, and malster in the present agricultural geography of the principal producing region. The last half of the book, and 38 of the maps, deal with the ecological factors related to the modern distributional patterns of American barley production and the "present" (i.e. 1940) decade in the North Central States. These sections are of immediate practical application to the grain men. For the geographer they carry forward, amplify, and map the important aspects of barley distribution, and add to the initial material presented by Weaver in the *Geographical Review*, Vol. 33, 1943, pp. 56–73 and 569–588.

Professor Weaver's excellent study is highlighted by maps of consistently high quality, and these are the outstanding features of the book. It is indeed fortunate that members of the barley organization will have access to a study of this kind, and to maps of this quality.

LOYAL DURAND, JR.

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YATES, FRANK. *Sampling Methods for Censuses and Surveys*. xiv and 318 pp.; diagrs., tables, bibliogr., index. Charles Griffin & Co., Ltd., London, and Hafner Publishing Co., Inc., New York, 1949. $5.50. 9¼ x 6¼ inches.

In its simplest form the process known as sampling is as old as the human ability to discriminate and select a small part to represent the whole. But just as the first apple may not be representative, being the only one rotten in the entire barrel, so selecting a sample requires the utmost care if it is not to form the basis for a totally mistaken generalization. Dr. Frank Yates of the Rothamsted Experimental Station prepared *Sampling Methods for Censuses and Surveys* in response to a request of the United Nations Sub-Commission on Statistical Sampling. With this book the author has done a considerable service by presenting a singularly comprehensive view, showing the advantages, limitations, and pitfalls of the process of sampling for censuses and surveys. He deals with his theme in simple terms with a minimum of mathematical explanation, omitting the laborious proofs perhaps required by the mathematical statisticians but entirely wasted on all but these numerically limited specialists.

Although the means taken by Dr. Yates in presenting sampling methods has been to show the development of these methods in the execution of a census or survey, and although geographers would rarely make use of just these procedures, there are ample and important lessons to be learned by our profession in studying this book. Sampling by various reconnaissance or traverse line methods is in common use in geographic field work. Recently this work has been greatly facilitated by the availability of aerial photographs which reveal much that is permissive of cartographic exterpolation. It is high time that greater thought be given to careful field reconnaissance and to the evaluation of statistical-cartographic portrayals of the distribution of census and other data with a view to selecting representative areas for detailed areal case-study analysis. The time should come when these detailed studies are given new meaning as samples representative of the distributional structure of phenomena which cannot possibly be mapped in full detail by our numerically limited professional man power. Increasing attention must be given by the geographer to sound sampling principles, and the illustrations given by Dr. Yates deserve careful study in order that new applications can be developed for the techniques of geographic field mapping. Geographers, too, must learn to sample wisely and stop wasting effort on detailed mapping representative of nothing so much as haphazard selection.

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